

Name: Key Date: 2018

Use the following to answer questions 1-5:

From the following list of observations, choose the one that most clearly supports the following conclusion:

- a) emission spectrum of hydrogen
- b) the photoelectric effect
- c) scattering of alpha particles by metal foil
- d) diffraction
- e) cathode "rays"

D

1. Electrons have wave properties.

- A) observation a
- B) observation b
- C) observation c
- D) observation d
- E) observation e

D

2. Electromagnetic radiation has wave characteristics.

- A) observation a
- B) observation b
- C) observation c
- D) observation d
- E) observation e

E

3. Atoms contain electrons.

- A) observation a
- B) observation b
- C) observation c
- D) observation d
- E) observation e

Thomson discovered electrons - cathode ray tube experiment.

A

4. Electrons in atoms have quantized energies.

- A) observation a
- B) observation b
- C) observation c
- D) observation d
- E) observation e

Bohr's bright line spectrum experiment

5. de Broglie wavelengths.

- A) observation a
- B) observation b
- C) observation c
- D) observation d
- E) observation e

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

momentum

$$E_{\text{photon}} = \frac{hc}{\lambda}$$

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

$$E_{\text{photon}} = h\nu$$

6. In an investigation of the electronic absorption spectrum of a particular element, it is found that a photon having $\lambda = 500 \text{ nm}$ provides just enough energy to promote an electron from the second quantum level to the third. From this information, we can deduce

- A) the energy of the $n = 2$ level.
- B) the energy of the $n = 3$ level.
- C) the sum of the energies of $n = 2$ and $n = 3$.
- D) the difference in energies between $n = 2$ and $n = 3$.
- E) all of these

$$\Delta E = -2.187 \times 10^{-18} \left(\frac{1}{3^2} - \frac{1}{2^2} \right)$$

7. Which form of electromagnetic radiation has the longest wavelengths?

- A) gamma rays
- B) microwaves
- C) radio waves
- D) infrared radiation
- E) x-rays

low E
low ν

8. Light can have a wavelength of 504 nm. The energy of a photon of light is

- A) $1.00 \times 10^{-31} \text{ J}$
- B) $5.04 \times 10^{-7} \text{ J}$
- C) $3.94 \times 10^{-19} \text{ J}$
- D) $5.95 \times 10^{14} \text{ J}$
- E) $2.54 \times 10^{18} \text{ J}$

$$c = \lambda \nu$$

$$\nu = \frac{2.998 \times 10^8 \text{ m/s}}{504 \times 10^{-9} \text{ m}} = 5.95 \times 10^{14} \frac{1}{\text{s}}$$

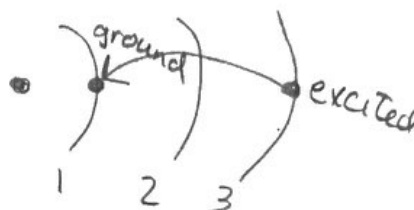
$$E = h\nu$$

$$= (6.626 \times 10^{-34} \text{ Js}) (5.95 \times 10^{14} \frac{1}{\text{s}})$$

$$= 3.94 \times 10^{-19} \text{ J}$$

9. When a hydrogen electron makes a transition from $n = 3$ to $n = 1$, which of the following statements is *true*?

- I. Energy is emitted. **T**
 II. Energy is absorbed. **F**
 III. The electron loses energy. **T**
 IV. The electron gains energy. **F**
 V. The electron cannot make this transition. **F**



- A) I, IV
 B) I, III
 C) II, III
 D) II, IV
 E) V

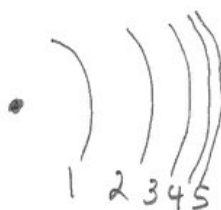
Use the following to answer question 10:

Consider the following portion of the energy-level diagram for hydrogen:

$n = 4$	$-0.1361 \times 10^{-18} \text{ J}$
$n = 3$	$-0.2420 \times 10^{-18} \text{ J}$
$n = 2$	$-0.5445 \times 10^{-18} \text{ J}$
$n = 1$	$-2.178 \times 10^{-18} \text{ J}$

10. For which of the following transitions does the light emitted have the longest wavelength?

- A) $n = 4$ to $n = 3$
 B) $n = 4$ to $n = 2$
 C) $n = 4$ to $n = 1$
 D) $n = 3$ to $n = 2$
 E) $n = 2$ to $n = 1$



Smallest Energy

11. In Bohr's atomic theory, when an electron moves from one energy level to another energy level more distant from the nucleus

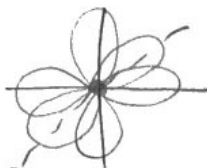
- A) energy is emitted.
 B) energy is absorbed.
 C) no change in energy occurs.
 D) light is emitted.
 E) none of these

12. Which of the following statements about quantum theory is *incorrect*?

- A) The energy and position of an electron cannot be determined simultaneously. $T \rightarrow$ Heisenberg Uncertainty Principle
 B) Lower energy orbitals are filled with electrons before higher energy orbitals.
 C) When filling orbitals of equal energy, two electrons will occupy the same orbital before filling a new orbital. $F \rightarrow$ Hund's Rule
 D) No two electrons can have the same four quantum numbers. $T \rightarrow$ Aufbau Principle
 E) All of these are correct. $T \rightarrow$ Pauli Exclusion Principle

13. A given set of *p* orbitals consists of _____ orbitals.

- A) 1
 B) 2
 C) 3
 D) 4
 E) 5



14. Which of the following combinations of quantum numbers is not allowed?

- | | n | l | m_l | m_s |
|----|-----|-----|-------|----------------|
| A) | 1 | 1 | 0 | $\frac{1}{2}$ |
| B) | 3 | 0 | 0 | $-\frac{1}{2}$ |
| C) | 2 | 1 | -1 | $\frac{1}{2}$ |
| D) | 4 | 3 | -2 | $-\frac{1}{2}$ |
| E) | 4 | 2 | 0 | $\frac{1}{2}$ |

$\rightarrow l=1=p$
 Energy level 1 has
 no *p* orbitals

15. Who was the first chemist to recognize patterns in chemical properties of the elements?

- A) Medeleev \rightarrow Mendeleev \rightarrow arranged by atomic mass
 B) Newlands \rightarrow Octaves
 C) Meyer
 D) Dobereiner \rightarrow found several groups of 3 that had similar properties (Triads)
 E) Bohr

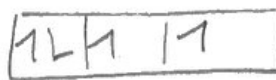
1872

Moseley \rightarrow atomic #

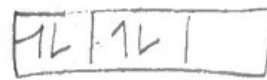
B 16. The statement that "the lowest energy configuration for an atom is the one having the maximum number of unpaired electrons allowed by the Pauli principle in a particular set of degenerate orbitals" is known as

- A) the aufbau principle.
 B) Hund's rule.
 C) Heisenberg uncertainty principle.
 D) the Pauli exclusion principle.
 E) the quantum model.

Hunds Rule



yes!



no!

E 17. Which of the following atoms would have the largest second ionization energy?

- A) Mg → second e⁻ is (3s)
 B) Cl → second e⁻ is 3p⁴
 C) S → " " " 3p³
 D) Ca → " " " 4s¹
 E) Na → " " " 2p⁶

→ closest to nucleus

C 18. An element has the electron configuration [Kr]5s²4d¹⁰5p². The element is a(n)

- A) nonmetal.
 B) transition element.
 C) metal.
 D) lanthanide.
 E) actinide.

Sn (tin)

but has multiple oxidation states (like transition metals)

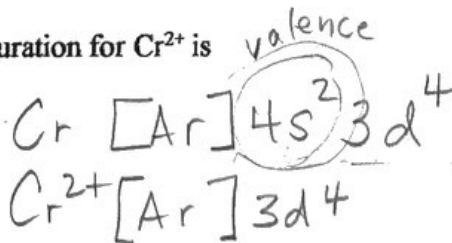
A 19. An element with the electron configuration [Xe]6s²4f¹⁴5d⁷ would belong to which class on the periodic table?

- A) transition elements
 B) alkaline earth elements
 C) halogens
 D) rare earth elements
 E) none of the above

Ir

C 20. The electron configuration for Cr²⁺ is

- A) [Ar]4s²3d⁴
 B) [Ar]4s¹3d⁵
 C) [Ar]3d⁴
 D) [Ar]4s²3d²
 E) none of these



B 21. Germanium has _____ in its 4p orbitals.

- A) 1 electron
- B) 2 electrons
- C) 3 electrons
- D) 4 electrons
- E) none of these

E 22. In which groups do all the elements have the same number of valence electrons?

- A) P, S, Cl
- B) Ag, Cd, Ar
- C) Na, Ca, Ba
- D) P, As, Se
- E) none

D 23. Of the following elements, which needs three electrons to complete its valence shell?

- A) Ba
- B) Ca
- C) Si
- D) P
- E) Cl

24. A line in the spectrum of atomic mercury has a wavelength of 253 nm. When mercury emits a photon of light at this wavelength, the frequency of this light is

- A) $8.44 \times 10^{-16} \text{ s}^{-1}$
- B) $7.85 \times 10^{-19} \text{ s}^{-1}$
- C) $1.18 \times 10^{15} \text{ s}^{-1}$
- D) 75.8 s^{-1}
- E) none of these

$$c = \lambda \nu$$

$$\nu = \frac{c}{\lambda} = \frac{2.998 \times 10^8 \text{ m/s}}{253 \times 10^{-9} \text{ m}}$$

$$= 1.18 \times 10^{15} \text{ s}^{-1}$$

25. Which statements about hydrogen are true?

- I. H has a lower ionization energy than He. T
 II. H^- is smaller than H. F
 III. H bonds with the halogens to form polar covalent compounds. T
 IV. H is always a metal. F
 V. H does not have a second ionization energy. T

Have not learned this yet.

- A) I, V
 B) II, IV
 C) I, III, V
 D) II, IV, V
 E) I, III, IV, V

26. Which of the following electron configurations are different from those expected?

- A) Ca
 B) Sc
 C) Ti
 D) V
 E) Cr

Exceptions to the filling order.



27. Order the elements S, Cl, and F in terms of increasing ionization energy.

- A) S, Cl, F
 B) Cl, F, S
 C) F, S, Cl
 D) F, Cl, S
 E) S, F, Cl

28. Order the elements S, Cl, and F in terms of increasing atomic radii.

- A) S, Cl, F
 B) Cl, F, S
 C) F, S, Cl
 D) F, Cl, S
 E) S, F, Cl

29. The first ionization energy of Mg is 735 kJ/mol. The second ionization energy is

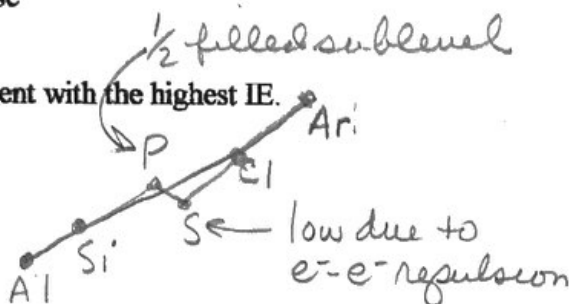
- A) 735 kJ/mol
 B) less than 735 kJ/mol
 C) greater than 735 kJ/mol
 D) More information is needed to answer this question.
 E) none of these

30. Which of the following exhibits the correct orders for both atomic radius and ionization energy, respectively? (smallest to largest)

- A) S, O, F, and F, O, S
- B) F, S, O, and O, S, F
- C) S, F, O, and S, F, O
- D) F, O, S, and S, O, F
- E) none of these

31. Choose the element with the highest IE.

- A) Na
- B) Mg
- C) Al
- D) P
- E) S

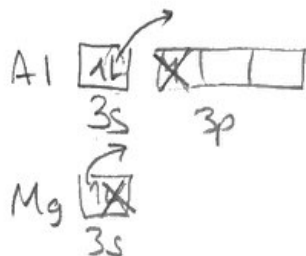


32. Which of the following is the highest energy orbital for a silicon atom?

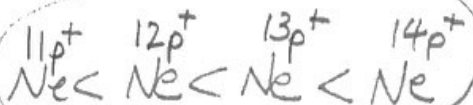
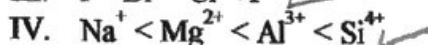
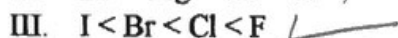
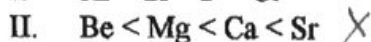
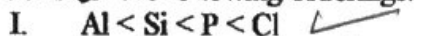
- A) 1s
- B) 2s
- C) 3s
- D) 3p
- E) 3d

33. Which of the following concerning second IE's is true?

- A) That of Al is higher than that of Mg because Mg wants to lose the second electron, so it is easier to take the second electron away. ~~X~~
- B) That of Al is higher than that of Mg because the electrons are taken from the same energy level, but the Al atom has one more proton.
- C) That of Al is lower than that of Mg because Mg wants to lose the second electron, thus the energy change is greater. ~~X~~
- D) That of Al is lower than that of Mg because the second electron taken from Al is in a p orbital, thus it is easier to take.
- E) The second ionization energies are equal for Al and Mg. NO



lowest highest
 34. Consider the following orderings.

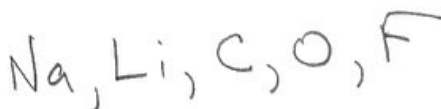


Which of these give(s) a correct trend in ionization energy?

- A) III
 B) I, II
 C) I, IV
 D) I, III, IV
 E) none of them

B 35. List the following atoms in order of increasing ionization energy: Li, Na, C, O, F.

- A) $\text{Li} < \text{Na} < \text{C} < \text{O} < \text{F}$
 B) $\text{Na} < \text{Li} < \text{C} < \text{O} < \text{F}$
 C) $\text{F} < \text{O} < \text{C} < \text{Li} < \text{Na}$
 D) $\text{Na} < \text{Li} < \text{F} < \text{O} < \text{C}$
 E) $\text{Na} < \text{Li} < \text{C} < \text{F} < \text{O}$



A 36. Consider the ionization energy (IE) of the magnesium atom. Which of the following is not true?

- A) The IE of Mg is lower than that of sodium. F
 B) The IE of Mg is lower than that of neon. ✓
 C) The IE of Mg is lower than that of beryllium. ✓
 D) The IE of Mg is higher than that of calcium. ✓
 E) The IE of Mg is lower than that of Mg^+ . ✓

A 37. Of the following elements, which has the lowest first ionization energy?

- A) Ba
 B) Ca
 C) Si
 D) P
 E) Cl



E 38. Of the following elements, which is most likely to form a negative ion with charge 1-?

- A) Ba^{2+}
 B) Ca^{2+}
 C) Si $4+$ or $4-$
 D) P^{3-}
 E) Cl^{1-}

C 39. Which of the following atoms has the largest ionization energy?

- A) O
B) Li
C) Ne
D) Be
E) K

→ has the most protons in its group.

40. For the set of elements Be, B, C, and N, which element has the smallest ionization energy? Explain any deviation from the expected pattern.

41. For the set of elements ^{Period 2} Li, O, Ne, and ^{Period 3} Na, which element has the largest atomic radius? Explain any deviation from the expected pattern.

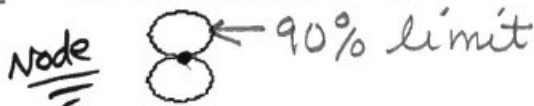
No deviations

→ period 3 - bigger

A 42. Which of the following statements is true?

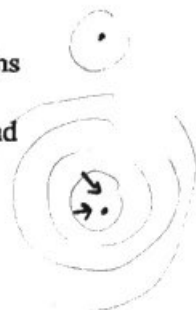
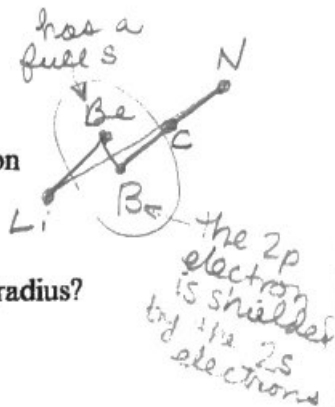
- A) The krypton 1s orbital is smaller than the helium 1s orbital because krypton's nuclear charge draws the electrons closer. **T**
B) The krypton 1s orbital is larger than the helium 1s orbital because krypton contains more electrons.
C) The krypton 1s orbital is smaller than the helium 1s orbital because krypton's p and d orbitals crowd the s orbitals.
D) The krypton 1s orbital and helium 1s orbital are the same size because both s orbitals can only have two electrons.
E) The krypton 1s orbital is larger than the helium 1s orbital because krypton's ionization energy is lower so it's easier to remove electrons.

E 43. Consider the following representation of a 2p-orbital:



Which of the following statements best describes the movement of electrons in a p-orbital?

- A) The electrons move along the outer surface of the p-orbital, similar to a "figure 8" type of movement.
B) The electrons move within the two lobes of the p-orbital, but never beyond the outside surface of the orbital.
C) The electrons are concentrated at the center (node) of the two lobes.
D) The electrons are only moving in one lobe at any given time.
E) The electron movement cannot be exactly determined.



44. Which of the following statements are false?

- takes more energy because of e-e repulsion*
- F** I. It takes less energy to add an electron to nitrogen than to carbon because nitrogen will be closer to achieving a noble gas configuration.
- F** II. It takes more energy to add an electron to fluorine than to oxygen because the radius of fluorine is smaller and more repulsion would occur in the *p*-orbitals. *less E because of eff. nuclear charge greater in F*
- T** III. It takes more energy to add an electron to nitrogen than to carbon because of the extra repulsions that would result in the *2p* orbitals.
- T** IV. It takes less energy to add an electron to iodine than to chlorine because the radius of iodine is larger and the electron is added at a distance further from the nucleus.
- A) II, III
 B) I, II, IV
 C) III only
 D) I, II
 E) All of the above are false statements.
- eat ↑*
lead ↓

45. For the elements Cs, F, and Cl, the order of increasing electronegativity is:

- B**
- A) $F < Cl < Cs$
 B) $Cs < Cl < F$
 C) $Cl < Cs < F$
 D) $F < Cs < Cl$
 E) None of these

Cs, Cl, F
Cs < Cl < F

46. Metals typically have _____ electronegativity values.

- B**
- A) high
 B) low
 C) negative
 D) no
 E) two of these

47. Which of the following has the smallest radius?

- A**
- A) K^+ [Ar]
 B) Cl^- [Ar]
 C) Rb^+ [Kr]
 D) S^{2-} [Ar]
 E) Ar

most p⁺

48. Which of the following pairs is isoelectronic?

- A) Li^+ and K^+
 B) Na^+ and Ne
 C) I^- and Cl^-
 D) S^{2-} and Ne
 E) Al^{3+} and B^{3+}

49. The first electron affinity value for oxygen is $(-)$ and the second electron affinity value is $(+)$.

- A) unfavorable (endothermic), favorable (exothermic)
 B) unfavorable (endothermic), unfavorable (endothermic)
 C) favorable (exothermic), favorable (exothermic)
 D) favorable (exothermic), unfavorable (endothermic)
 E) More information is needed.

50. Which of the following have 10 electrons in the d orbitals?

- A) Mn
 B) Fe
 C) Cu
 D) Zn
 E) two of the above

→ exception to the filling order
 at $\underline{3d^4} \uparrow \underline{3d^9}$