1. If the average bond energy for the C-H bond in methane is 435 kJ/mol. What frequency of light is needed to break the bond?

a. 6.67 e35 Hz
b. 1.09 e15 Hz
c. 6.57 e38 Hz
d. 1.09 e12 Hz

((435000 J/mol)*(1 mol/6.022 e23 photons))/(6.626 e-34 J*) = 1.09 e15 Hz

2. Which of the following statements is incorrect?

a. The wavelength of light emitted by black body radiators decreases as the temperature of the body increases.
b. The kinetic energy of electrons ejected by photons increases as the frequency of the incident radiation increases.
c. The wavelength of matter is inversely proportional to mass.
d. Photons of any wavelength will eject electrons from metal surfaces.

Explanation: There is a minimum energy and, therefore, a minimum wavelength, necessary to eject electrons from metal surfaces. This is called the photoelectric effect.

3. If an electron falls to the energy level n=1, and an emission spectrum was observed at 102.3 nm, what energy level did it fall from? n=

a. 2
b. 3
c. 4
d. 5

c/ λ = v
(3 e8 m/s)/102.3 e-9 m = 2.93 e15 Hz
v = R (1/nl^2 - 1/nu^2)
nu = (1/nl^2 - v/R)^(-1/2)
nu = (1/1^2 - 2.93 e15 Hz/3.3 e15 Hz)^(-1/2) = 3

4. If a particle is in a one-dimensional box of length 200 cm and is in its fourth energy level, at which of the following positions is the particle least likely to be found?

a. 100 cm
b. 75 cm
c. 125 cm
d. 130 cm

The fourth energy level will have nodes at 50, 100 and 150 cm.

5. If the uncertainty in the position of a particle is 2.4 cm, what is the minimum uncertainty in the particles momentum?

a. 2.2 e-35 m/s
b. 4.4 e-33 m/s
c. 2.2 e-33 m/s
d. 4.4 e-35 m/s

$\Delta p \Delta x \geq \hbar/2$
$\Delta p \geq \hbar/(2*\Delta x)$
$\Delta p \geq$ (1.05 e-34 Js)/(2*.024 m) = 2.2 e-33 m/s

6. What is the wavelength of a particle with a momentum of 745 kg*m/s?

a. 9.47 e-36 m
b. 8.89 e-37 m
c. 1.41 e-37 m
d. 2.82 e-36 m

λ = h/(mv) = h/p = 6.626 e-34 Js/745 kg*m/s = 8.89 e-37 m

7. Consider the species below. All of them will have the same number of V(r) terms in their respective solutions to the Schrodinger equation except for one of them. Which is the odd one out?

a. Ar
b. K^+
c. S^{2-}
d. Sc^+

The number of V(r) terms in a given solution to the Schrodinger equation is determined by the number of electrons. All of the species listed have the same number of electrons except for Sc^+.

8. Which of the following quantum number values could apply to the valence electrons of platinum?
a. n = 5, l = 4, ml = 3, ms = -1/2
b. n = 5, l = 5, ml = 3, ms = 1/2
c. n = 5, l = 4, ml = 2, ms = -1/2
d. n = 6, l = 4, ml = 2, ms = 1/2

9. What is the total number of electrons that could be described by the quantum numbers n = 5 and m_l = 3?
a. 4 electrons
b. 10 electrons
c. 50 electrons
d. 25 electrons
e. 5 electrons
f. 12 electrons

For n equal to 5, possible values of l are 0, 1, 2, 3 and 4. And for m_l equal to 3, possible values of l are 3 and greater. Combining these two constraints, these numbers could describe an individual orbital of the type 5f or 5g, each of which could hold two electrons for a total of 4 electrons.

10. Which of the following is an incorrect statement?
a. Br- and Rb+ have the same electronic configuration.
b. The Pauli Exclusion Principle is primarily concerned with the quantum number ms.
c. Because of Hund's rule, nitrogen has one electron in each of its three 2p orbitals.
d. The electron configuration of silver, [Kr] 5s1 4d10, is in apparent violation of the Aufbau Principle.

11. Which set of atoms and ions all have the same electronic configuration?
a. F-, Cl-, Br-, I-
b. C, N, O, F
c. O2-, Mg2+, F-, Ne
d. Ar, Cl-, K, Ca2+

Only the set of species which is isoelectronic will have the same electron configuration.

12. Which of the following species have the same electronic configuration?
I. Sn4+
II. Cd
III. Ag+
IV. In 3+
a. I, II, III, IV
b. I, III, IV
c. I and IV only
d. II and IV only
e. II and III only
f. none

Species I, III, and IV are all in a [Kr] 4d10 configuration. Cd has a configuration of [Kr] 5s2 4d10.

13. Which of the following species is/are exceptions to the Aufbau order?
I. Nb

II. Sn
III. Rh^+

a. I
b. II
c. III
d. I and II
e. I and III
f. II and III
g. none

Nb, Sn and Rh^+ all have electron configurations which follow the Aufbua order simply.

14. Members of which group are commonly found as dications?

a. noble gases
b. halogens
c. lanthanides
d. alkaline earth metals
e. alkali metals

The second group of the periodic table, the alkaline earth metals, exist as dications. Example: Ca^{2+}.

15. The effective nuclear charge (ENC) experienced by an element's 1s electrons (increases/decrease/stays the same) as the atomic number increases and (increases/ decreases/stays the same) as a given element is ionized by removing electrons.

a. increases, decreases
b. decreases, decreases
c. stays the same, increases
d. increases, stays the same
e. stays the same, stays the same
f. decreases, increases

Atomic number corresponds to the number of protons in the nucleus and as that values increases, the ENC experienced by the innermost (i.e. 1s) electrons increases. Ionization, removal of valence electrons, will in no way impact the ENC experienced by the innermost electrons.

16. Select the appropriate trend and explanation for ionization energy in the periodic table:

a. Increases down a group and across a period; the effective nuclear charge is also increasing.
b. Decreases down a group and across a period; the addition of more electrons makes it easier to remove them.
c. Increases down a group and decreases across a period;the effective nuclear charge decreases across a period due to the addition of electrons.
d. Decreases down a group and increases across a period; shielding increases down a group and decreases across a period.

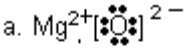
Ionization energy is related to effective nuclear charge. Going down a group more energy
levels are added, therefore the valence electrons will be more shielded and easier to remove. Across a period the electrons are added to the same energy level and experience no shielding from electrons in the same period. Hence, when going across a period it is more difficult to remove electrons.

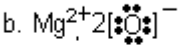
17. Rank the following elements in order of increasing electron affinity: Cl, Zn, Li, Cu

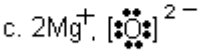
a. Li < Cu < Zn < Cl
b. Cl < Zn < Cu < Li
c. Zn < Li < Cu < Cl
d. Cl < Cu < Li < Zn

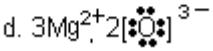
Zn has a full d subshell, which is stable and does not need another electron. Chlorine is one electron away from noble gas configuration and therefore has a very high affinity. Copper is one electron away from a full d subshell. Li will readily lose electrons.

18. Which of the following is the best representation of magnesium oxide?

a. 

b. 

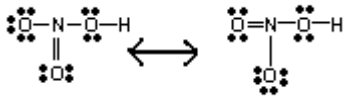
c. 

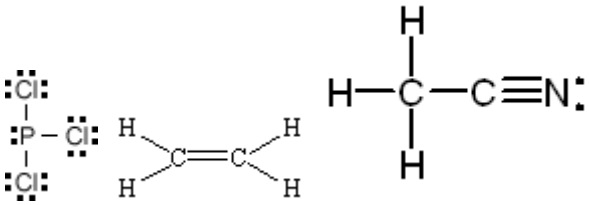
d. 

a. Magnesium will lose two electrons to oxygen.

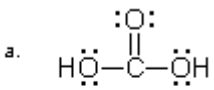
19. Which of the following compounds show resonance?
    a. HNO3
    b. C2H3N
    c. C2H4
    d. PCl3

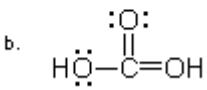
Compounds that show resonance must have the same atoms connected to each other in all structures. Only electrons can be shifted in resonance structures, not atoms.

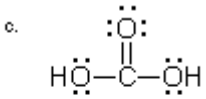


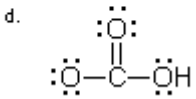


20. Which of the following most represents H2CO3

a. 

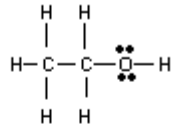
b. 

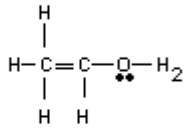
c. 

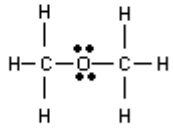
d. 

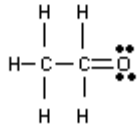
a. All other structures have too many electrons or missing an atom.

21. Which of the following best represents ethanol, C2H6O. (may be more than one correct answer)

a. 

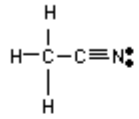
b. 

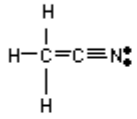
c. 

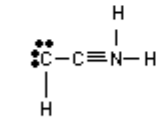
d. 

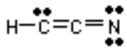
a. Ethanol is an alcohol and must have an alcohol group (-OH), but you aren't required to know this right now. Therefore, C can't be correct because there's no alcohol group.

22. Which best represents C2H3N

a. 

b. 

c. 

d. 

A.

23. Which of the following can more than four bonds?
   a. Oxygen
   b. Chlorine
   c. Sulfur
   d. Carbon

Sulfur is the only one with more than 10 electrons.

24. Which of the following can never have four bonds?

a. Boron
b. Oxygen
c. Nitrogen
d. Carbon

Boron has only 3 valence electrons to bond.

25. How does nitric oxide, NO, violate the octet rule?
a. More than 8 electrons are shared
b. Less than 8 electrons are shared
c. The compound contains an odd number of electrons

26. Rank from lowest to highest in crystal lattice energy:NaCl, AlF3, MgO
a. NaCl < MgO < AlF3
b. AlF3 < MgO < NaCl
c. MgO < NaCl < AlF3
d. AlF3 < NaCl < MgO

The electrostatic attraction is greatest for AlF3. Al3+ is the most charged ion. Mg+2 is the second most charged an Na+ is the least.

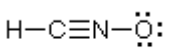
27. Rank the following in order of increasing difference in electronegativity: H_2O, O_2, NH_3
a. $H_2O < O_2 < NH_3$
b. $O_2 < NH_3 < H_2O$
c. $H_2O < NH_3 < O_2$
d. $O_2 < H_2O < NH_3$

Any diatomic molecule will have a difference in electronegativity of 0. Oxygen has a higher electronegativity than nitrogen.

28. Determine the formal charges for chlorate, ClO_3^-
a. Cl = +2, O = -1
b. Cl = 0, O = -1
c. Cl = 0, O = -2
d. Cl = -1, O = 0

Chlorine has more than 10 electrons and can therefore violate the octet rule. Without this violation chlorine would have a +2 charge. However, to make Cl neutral a lone pair from two of the oxygens are used to make twp double bonds. The remaining oxygen has the -1 charge.

29. Determine the correct formal charges for nitrogen and oxygen in



a. N = -1, O = +1
b. N = +1, O = -1
c. N = 0, O = 0
d. N = +1, O = 0

Formal charge = # of valence e - (# of nonbonding e + 1/2 # bonding e)

30. Which of the following are true:
I. Electronegativity increases with increasing effective nuclear charge
II. Bond energy decreases with increasing bonding
III. A double bond is longer than a single bond
a. I
b. I, III
c. II, III
d. I, II, III

A double bond has more energy than a single bond. The length between atoms decreases as more bonds are added between them.