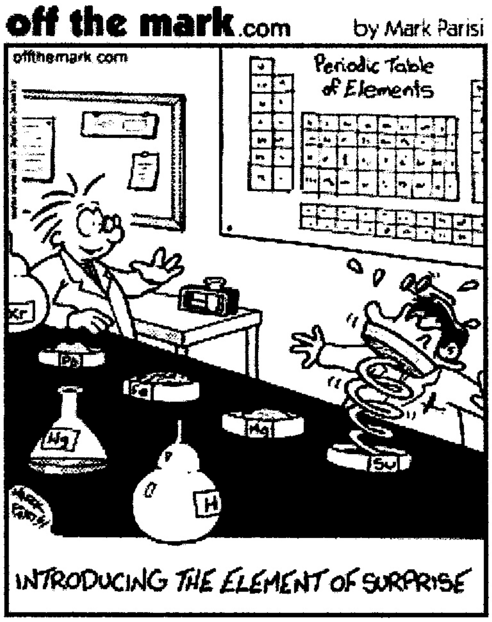
Exam #3- Version 32

Name: Answer Key

Instructions:

- Fill in your name and student number on the scan sheet.
- Fill in the exam version number as listed above on the scan sheet.
- Record your answers both here and on the scan sheet. **Hand in the scan sheet and the last page of the exam (questions 26 and 27)**; take this copy of the exam with you when you leave.
- As always, the last page is the Periodic Table. You may tear it off and use it for the exam.



© Mark Parisi, Permission required for use.

1. Which of the following has the highest energy?
   [✓ a. A *1s* orbital in a Na atom]
   b. A *1s* orbital in an Al atom
   c. A *1s* orbital in a P atom
   d. A *1s* orbital in an Ar atom
   e. None of the above. All *1s* orbitals have the same energy.

Orbital energy decreases as you go from L → R across a period/row.

2. Only one set of quantum numbers listed below is an allowed set. Which one? (n, l, m_l, m_s)
   [✓ a. 3, 2, 0, ½]
   b. 2, 2, -2, ½
   c. 3, 3, -3, ½
   d. 4, 4, -3, ½
   e. none of these

l cannot be the same as n (l can be from $0 \rightarrow n-1$)

3. What are the possible m_ℓ values for *3d* electrons?

↳ m_l can go from $-l$ to $+l$

l for a d orbital is 2

  a. 0, 1, 2

  b. 1, 2, 3

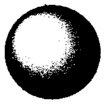
  c. -1, 0, +1

  [✓ d. -2, -1, 0, +1, +2]

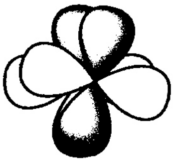
  e. None of the above. There are no 3d orbitals.

4. Which of the following shapes listed below would represent one of three possible *2p* atomic orbitals?

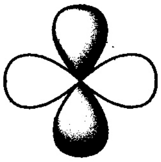
[✓ a.]



b. s orbital



c. f orbital



d.

e.

d orbitals

Questions 5-13 refer to the table below. Each term is assigned a letter. Fill in the letter on the scan sheet that corresponds to the appropriate term.

a. PAULI EXCLUSION PRINCIPLE	b. HEISENBERG UNCERTAINTY PRINCIPLE	c. AUFBAU PRINCIPLE
d. BOHR MODEL	e. PRINCIPAL QUANTUM NUMBER (n)	f. SPIN QUANTUM NUMBER (m_s)
g. ANGULAR MOMENTUM QUANTUM NUMBER (l)	h. MAGNETIC QUANTUM NUMBER (m_l)	i. EMISSION

5. States that no two electrons can have the same four quantum numbers. A

6. As this increases, the size of an orbital increases. E

7. States that the energy and exact position of an electron cannot be known at the same time. B

8. Can be used to explain the bright line spectrum of hydrogen. D

9. Occurs when there is an electronic transition from a higher energy state to a lower energy state. I

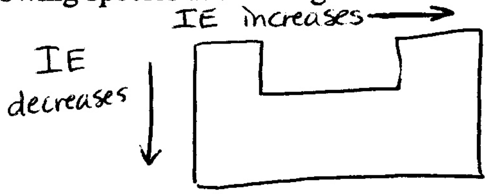
10. Gives information about the spatial orientation of an orbital. H

11. Only has two possible values; these are $^{+}½$ or $^{-}½$. F

12. Dictates that an electron will occupy the lowest energy orbital that is available. C

13. Gives the shape of an orbital. G

14. Which of the following species has the highest ionization energy?
    - a. Li
    - [✓ b. Be]
    - c. Ca
    - d. Ba
    - e. Cs



15. What is the correct electronic configuration for Arsenic (Z = 33) taking into account the proper order for filling subshells?

→ 3rd atom in the 4p block
33 electrons

- *a.* $1s^2 2s^2 2p^6 3s^2 3p^6$
- *b.* $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^3$
- *c.* $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2 4p^6 4d^{10} 4f^{14} 5s^2 5p^6 5d^6$
- [✓ *d.* $1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^3$]
- e. $[Kr]4p^3$

This is incorrect because the 4s fills before the 3d orbitals → b.

16. Which transition in a hydrogen atom represents the absorption with the ***least*** energy?
    - a. n=1 → n=2
    - b. n=3 → n=2
    - c. n=2 → n=1
    - d. n=4 → n=2
    - [✓ e. n=2 → n=5]

These are emissions (b.–d.)

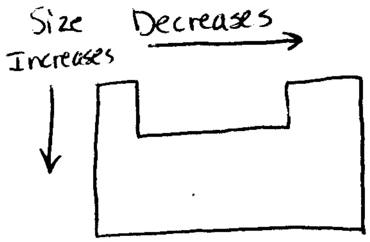
$\Delta E_{1\to2} = -2.18 \times 10^{-18} J \left(\frac{1}{2^2} - \frac{1}{1^2}\right) = -5.45 \times 10^{-19} J$ (larger)

↑ final ↑ initial

$\Delta E_{2\to5} = -2.18 \times 10^{-18} J \left(\frac{1}{5^2} - \frac{1}{2^2}\right) = -2.18 \times 10^{-20} J$ (smaller)

As you go up in n-level, the energy levels get closer together.

17. Which of the following series of atoms are arranged in order of <u>decreasing</u> size?
    - a. K > Ga > In   In > Ga
    - b. Cl > Br > Kr   Br > Cl
    - c. Li > Mg > Ca   Ca > Mg
    - d. H > He > Li   Li > He
    - [✓ e. none of these]



18. Which set of quantum numbers could describe a *3s* orbital?
    - a. $n = 2, \ell = 0, m_\ell = 0$
    - b. $n = 3, \ell = 1, m_\ell = 1$
    - c. $n = 2, \ell = 1, m_\ell = 1$
    - [✓ d. $n = 3, \ell = 0, m_\ell = 0$]
    - e. none of these

19. Arrange the species Cl^{-1}, K^{+1}, and S^{-2} in terms of *increasing radii.*

(Smallest) (Largest)

- a. $Cl^{-1} < S^{-2} < K^{+1}$
- b. $K^{+1} < S^{-2} < Cl^{-1}$
- c. $S^{-2} < Cl^{-1} < K^{+1}$
- d. $Cl^{-1} < K^{+1} < S^{-2}$
- [✓ e. $K^{+1} < Cl^{-1} < S^{-2}$]

cations < anions

anion size decreases as you go from L→R in the p-block (so $Cl^- < S^{2-}$)

20. The quantum number ℓ for an electron is 1. The electron is definitely located in:
    - a. the first principal shell
    - b. the second principal shell
    - c. an *s* subshell
    - [✓ d. a *p* subshell]
    - e. a *d* subshell

a., b. } given by n-number

$\ell = 1$ for p orbitals

21. What is the energy of a photon of light that has a frequency of 2.3×10^{14} Hz?
    - a. 2.8×10^{-18} J
    - [✓ b. 1.5×10^{-19} J]
    - c. 2.9×10^{-48} J
    - d. 6.4×10^{-22} J
    - e. none of these

$E_{photon} = h \cdot \nu = (6.626 \times 10^{-34} J \cdot s)(2.3 \times 10^{14} Hz)$

$\uparrow$ Hz = sec^{-1}

22. The ground state of which species below has the most unpaired electrons?
    - a. P → ↿ ↿ ↿ (3p) = 3 unpaired e⁻
    - b. O → ↿⇂ ↿ ↿ (2p) = 2 unpaired e⁻
    - c. Se → ↿⇂ ↿ ↿ (4p) = 2 unpaired e⁻
    - [✓ d. Fe] ← ↿⇂ ↿ ↿ ↿ ↿ (3d) 4 unpaired electrons
    - e. N → ↿ ↿ ↿ (2p) = 3 unpaired e⁻

23. What wavelength of light is emitted when an electron in a He^+ ion goes from the $n = 5$ shell to the $n = 2$ shell?
    - a. 2.30×10^{6} m
    - [✓ b. 4.34×10^{-7} m]
    - c. 1.08×10^{-7} m
    - d. 1.52×10^{-7} m
    - e. none of these

a 1e⁻ system, so: $E_n = -2.18 \times 10^{-18} J \left(\frac{1}{n^2}\right)$

$\Delta E_{5 \to 2} = -2.18 \times 10^{-18} J \left(\frac{1}{2^2} - \frac{1}{5^2}\right) = -4.58 \times 10^{-19} J$

$\lambda = \frac{h \cdot c}{\Delta E} = \frac{(6.626 \times 10^{-34} J \cdot s)(3 \times 10^{8} m/s)}{-4.58 \times 10^{-19} J} = 4.34 \times 10^{-7} m$

24. How many planar and how many spherical nodes will a $4d_{xz}$ orbital have?
    - a. a $4d_{xz}$ orbital has no nodes
    - b. one planar and one spherical
    - c. one planar and two spherical
    - d. two planar and no spherical
    - [✓ e. two planar and one spherical]

$n = 4 \quad \ell = 2$

planar = $\ell = 2$

spherical = $n - \ell - 1 = 4 - 2 - 1 = 1$

25. What is the maximum number of electrons that can occupy a "5g" sublevel?
    - a. 2
    - b. 5
    - c. 10
    - d. 14
    - [✓ e. 18]

s → 1 orbital = 2e⁻

p → 3 orbitals = 6 e⁻

d → 5 orbitals = 10e⁻

f → 7 orbitals = 14e⁻

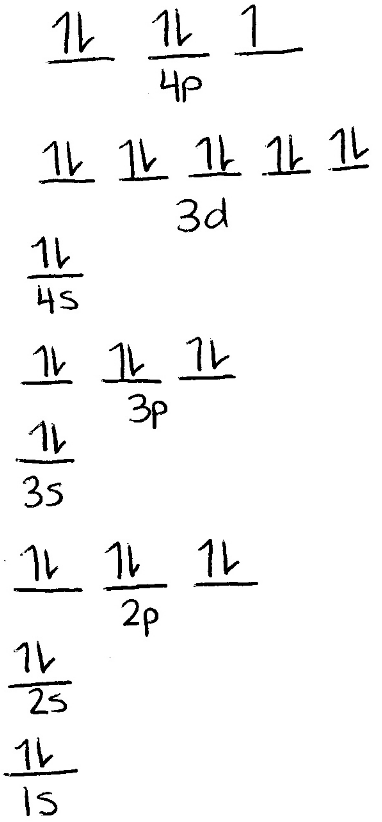
g → 9 orbitals = 18e⁻

Name: Version 32 Key

26. Draw the orbital box electron configuration for the element Br.

Br has 35 electrons.

Z = 35



27. Draw the orbital box electron configuration for the ion Br^{1-}.

Br^- has 36 electrons.