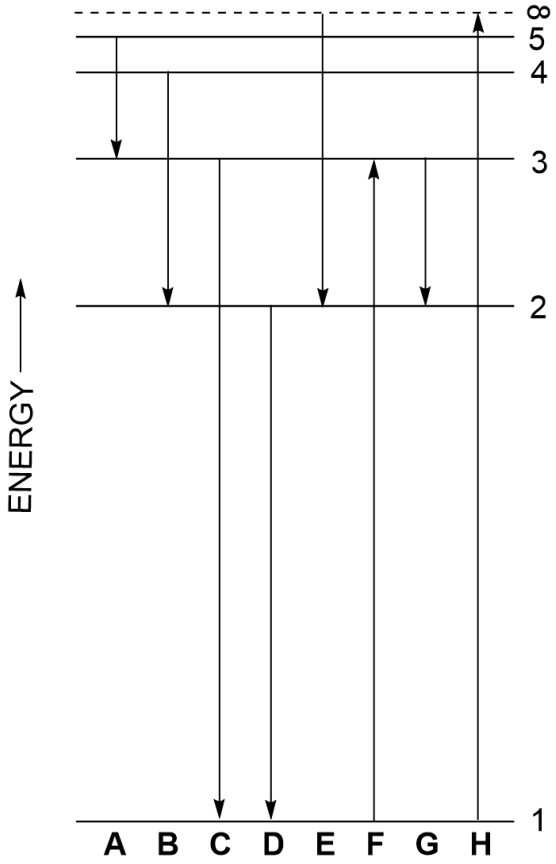
Electronic Structure and Periodic Properties Sample Test Questions Fall 2021

25/29

The number of sample questions does not reflect the number of questions that may appear on an In-term test.

Below is an energy level diagram for the possible energy levels of a hydrogen atom. Use it to answer the following three questions about the hydrogen atom.



1. Which of the transitions above involve the emission of the shortest wavelength photon?

A. A B. B C. C D. D E. E

2. Which of the transitions result in a ground state hydrogen atom?

A. C and D
B. B, E and G
C. A, B, E, F, G and H
D. H
E. F

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$n_i = 4$

$n_f = 2$

3. Calculate the wavelength (in nm) of the photon that is emitted during transition B.

A. 97 B. 410 C. 434 D. 486 E. 656

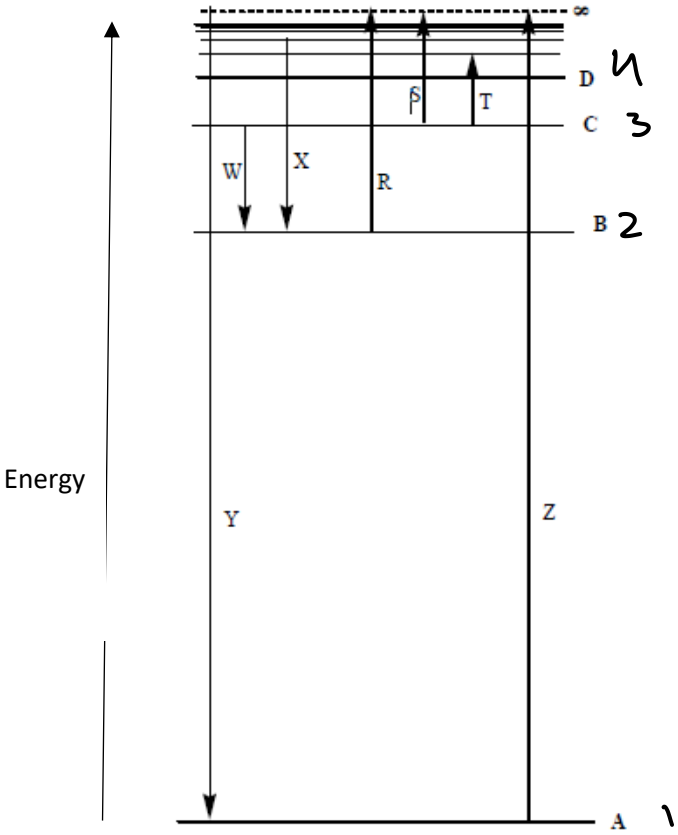
$$\Delta E = -2.18 \times 10^{-18} \left(\frac{1}{(2)^2} - \frac{1}{(4)^2} \right) = -4.0875 \times 10^{-19} \text{ J}$$

$E = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{E}$

$= 486 \text{ nm}$

Below is an energy level diagram for the possible energy levels of a hydrogen atom. Use it to answer the following two questions about the hydrogen atom.



4. Decide whether the following statements are true (T) or false (F) and then select the best response below for indicating the one(s) that is(are) FALSE.

i) Transition W represents an emission. ✓
ii) Transition R represents an ionization. ✓
iii) Transition T represents an absorption. ✓
iv) For the level labeled C the value of n is 3. ✓
v) Level D is the third excited state. ✓
vi) Transition S results in emission of radiation. ✗

A) iv & vi B) vi only C) v & vi D) iv, v & vi E) ii & v

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5. Using a formula from the DATA sheet, calculate the frequency (in s^{-1}) of the photon corresponding to transition Z.

A. 1.097×10^{7} B. 3.29×10^{15} C. 3.29×10^{-15} D. -3.29×10^{-15} E. 2.73

$$\nu = \left|3.29\times10^{15}\left(\frac{1}{\infty^2}-\frac{1}{1^2}\right)\right| = \left|3.29\times10^{15}(-1)\right| = 3.29\times10^{15}$$

6. An electron having $n = 3$ and $m_l = +1$

A. must have $m_s = +½$
B. must have $l = 1$
C. may have $l = 1$ or 2
D. must have $l = 2$
E. must be in a p orbital

$n = 3$
l: up to $n-1$
m_l range $= n^2 = 3^2 = 9$
so m_l: 0 -1 0 1 -2 -1 0 1 2

7. An atomic orbital represents:

A. the shape of an atom.
B. the repulsion of all the electrons among themselves.
C. a fixed path that an electron follows around the nucleus of an atom.
D. the region of high probability for an electron around the nucleus of an atom.
E. the region of electron density for a covalent bond.

8. What neutral ground state atom has the electronic structure $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^1\ 3d^{10}$?

A. Co B. Ni C. Cu D. Zn E. Ga

9. Which of the following is NOT a correct ground state electron configuration?

A. Al = [Ne] $3s^1\ 3p^2$ ✗
B. Se = [Ar] $4s^2\ 3d^{10}\ 4p^4$ ✓
C. H = $1s^1$ ✓
D. Ba = [Xe] $6s^2$ ✓
E. In = [Kr] $5s^2\ 4d^{10}\ 5p^1$ ✓

10. What is the correct electronic configuration for the Zr^{3+} ion (zirconium 3+)?

A. [Ar] $4d^1$
B. [Kr] $4d^1$
C. [Kr] $5s^1$
D. [Ar] $5s^1$
E. [Kr] $4d^2$

Zr = [Kr] $5s^2\ 4d^2$

Zr^{3+} = [Kr] $4d^1$

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11. If A > B means the atomic radius of A is greater than that of B, which of these pairs of elements is in the WRONG order with respect to their relative size?

A: Kr > Ga
B: Mg > S
C: Bi > S
D: I > Cl
E: Zr > Ru

12. Which of the following statements about orbitals is **CORRECT**?

A. The average distance from the nucleus of a 3*s* electron in a chlorine atom is smaller than that for a 3*p* electron on the same atom.
B. There is no experimental evidence that an electron behaves as if it has spin.
C. The 2*s* orbitals have a node at the nucleus.
D. The five 3*d* orbitals are alike except for the orientation with respect to the axes.
E. The quantum number *l* denotes the orientation of an orbital with respect to the other orbitals.

13. Calculate the effective nuclear charge (Z_{eff}) for a valence electron of chlorine (Cl) using the simplest possible model, namely that electrons in the same shell (same n) do not shield (screen) at all, and that all core electrons screen exactly one proton charge each.

17 - 10 = 7

A. Z_{eff} = 6.1 B. Z_{eff} = 5.0 C. Z_{eff} = 7.0 D. Z_{eff} = 6.0 E. Z_{eff} = 5.8

14. Consider the following electron configuration (written in Aufbau filling order). What neutral ground state element has this configuration?

$1s^2 2s^2 2p^6 3s^2 3p^6 4s^2 3d^{10} 4p^6 5s^2 4d^{10} 5p^6 6s^2 4f^{14} 5d^{10}$

A. Pb B. Hg C. Tl D. Cn E. Au

15. The predicted ground state electron configuration for the doubly charged ion of tungsten (W^{2+}) is?

A. [Xe] $4f^{14}\ 5d^4\ 6s^2$
B. [Xe] $4f^{13}\ 5d^5$
C. [Xe] $4f^{12}\ 5d^4\ 6s^2$
D. [Xe] $4f^{14}\ 5d^3\ 6s^1$
E. [Xe] $4f^{14}\ 5d^4$

$W = [Xe]\,6s^2\,4f^{14}\,5d^4$

$W^{2+} = [Xe]\,4f^{14}\,5d^4$

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16. What is the energy (in J) of **one mole** of photons with the energy of the 434 nm line in the hydrogen spectrum?

A. 2.76×10^{5}
B. 9.21×10^{-4}
C. 2.80×10^{-4}
D. 4.58×10^{-19}
E. 1.73×10^{-7}

E of one photon $= \frac{hc}{\lambda} = 4.58 \times 10^{-19}$ J

E of one mole $= 4.58 \times 10^{-19} \times 6.02 \times 10^{23}$
$= 2.76 \times 10^{5}$ J

17. How many electrons in a tellurium (Te) atom have a principal quantum number of n = 4 and a magnetic quantum number of $m_\ell = 0$?

A. 2 B. 3 C. 6 D. 9 E. 18

$n = 4$ $l_{max} = 3$ ∴ d orbital.

l	0	1	2	3
m_l	0	-1 0 1	-2 -1 0 1 2	-3 -2 -1 0 1 2 3

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

18. An electron is travelling with a velocity of 1.21×10^{6} m/s. The uncertainty in measuring its velocity is 10.0 m/s. What is the minimum uncertainty in measuring its position (in micrometers, µm). (1 µm = 10^{-6} m)

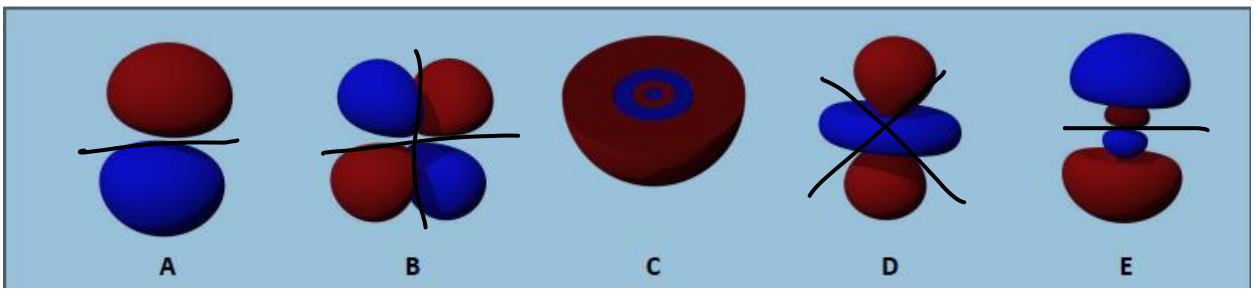
A. 5.79 B. 2.09 C. 423 D. 193 E. 478

$(\Delta x)(m\Delta v) \geq \frac{h}{4\pi}$

$\Delta x = \frac{h}{4\pi m \Delta v} = 5.79 \times 10^{-6}$ m

$\Delta v = 10$

Below are some depictions of orbitals. The next 3 questions refer to these pictures.



19. Which of these orbitals has(have) an ℓ value (angular momentum quantum number) of 1?

A. all of them B. A and E C. A and D D. A, D and E E. C only

20. Which of these pictures depict(s) a *d* orbital?

l =	0	1	2	3
	s	p	d	

A. all of them B. A and E C. B and D D. B, D and E E. B only

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d orbital
$l = 2$
$n = 3$

21. Which set of quantum numbers n,ℓ can be valid for the orbital D in the figure above?

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

22. Sodium-vapor streetlamps are efficient because they emit light at a wavelength of 589 nm, near the peak sensitivity of the human eye. A typical streetlamp runs at 100 watts (that is, 100 joules per second). How many photons would such a lamp emit in one second?

(A) 2.96×10^{20} B. 2.96×10^{18} C. 3.38×10^{-19} D. 3.38×10^{-17} E. 5.89×10^{4}

$E = \frac{hc}{\lambda} = 3.37 \times 10^{-19}\ J$ $\quad \frac{100\ J}{1\ s} = 3.37 \times 10^{-19}\ J \Rightarrow 3.37 \times 10^{20}$

1s = 100 J
$1\ s = 2.96 \times 10^{20}$

23. Which of the following phenomena can be explained by the classical wave theory of light?

A. blackbody radiation
B. the photoelectric effect
C. emission spectra
(D) destructive interference
E. none of A, B, C or D.

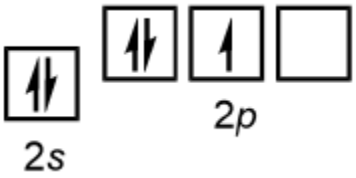
24. How many nodes are there in each of the 4s, 4p, 4d and 4f orbitals?

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

for all orbitals the number of nodes is given by $n-1$

	4s	4p	4d	4f
angular nodes	0	1	2	3
radial nodes	3	2	1	0

25. Inspect the electron configuration of the valence electrons in a nitrogen atom, and select the best description of this state.

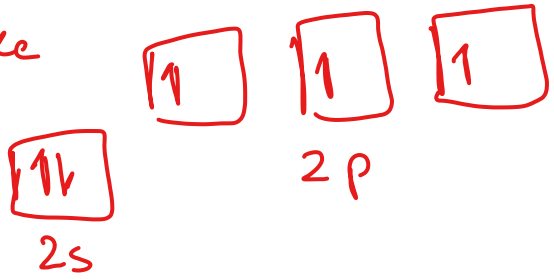


N = 5

(A) The ground state.
(B) An excited state.
C. A forbidden state.
D. An ionized state.
E. A state that disobeys the Pauli exclusion principle.

$N = [He]\ 2s^2\ 2p^3$

ground state would be like



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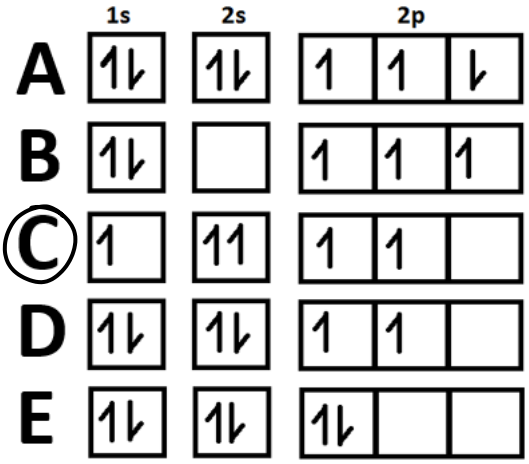
✓ 26. Which of the following is a violation of the Pauli Exclusion Principle?



✗ 27. Why does Beryllium (Be) have a positive electron affinity? (That is, how do we rationalize the fact that it is energetically unfavorable for a Be atom to accept an electron when it is energetically favorable for lithium (Li) and boron (B) to do so?)

A. It has a low Z_{eff}.
B. Occupying a higher energy subshell is energetically unfavorable.
C. It has a full shell of valence electrons.
D. Electron-electron repulsion between two electrons in the same 2p orbital is high.
E. Beryllium has a high electronegativity.

✗ 28. Which of these elements has the highest third ionization energy? ? Mg^{2+} = 2nd ionization because this is stable the third ionization energy would be reall high.

A. Al B. P C. Si D. Mg E. S

$Mg < Al < Si < P < S$

✓ 29. Which element from the set below has the largest negative (most favorable) electron affinity?

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

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Question	Answer
1	C
2	A
3	D
4	B
5	B
6	C
7	D
8	C
9	A
10	B
11	A
12	A
13	C
14	B
15	E
16	A
17	C
18	A
19	B
20	C
21	D
22	A
23	D
24	E
25	B
26	C
27	B
28	D
29	D