The Bohr Atom

Multiple Choice
Identify the letter of the choice that best completes the statement or answers the question.

____ 1. What is the energy of the emitted photon when an electron drops from the third energy level to the second energy level?
a. 1.51 eV
b. 1.89 eV
c. 2.27 eV
d. 4.91 eV

____ 2. What is the energy of an electron in the third energy level of a hydrogen atom?
a. -13.6 eV
b. -4.53 eV
c. -2.27 eV
d. -1.51 eV

____ 3. Which transition of an electron in a hydrogen atom will result in an energy release of 0.306 eV?
a. $n = 3$ to $n = 4$
b. $n = 4$ to $n = 3$
c. $n = 4$ to $n = 5$
d. $n = 5$ to $n = 4$

____ 4. What is the change in energy when an electron drops from $n = 3$ to $n = 1$?
a. 1.5 eV
b. 12.1 eV
c. 13.6 eV
d. 15.1 eV

____ 5. If the orbital radius of an electron in a hydrogen atom is 2.12×10^{-10} m, at what energy level is the electron?
a. 1^{st}
b. 2^{nd}
c. 4^{th}
d. 8th

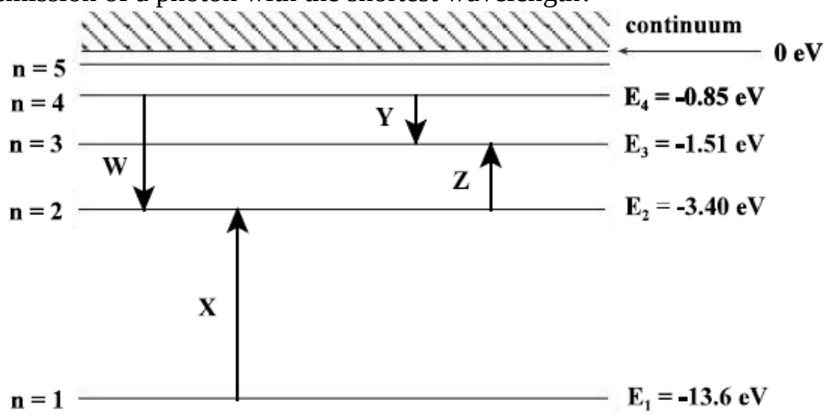
____ 6. If r_1 is the smallest orbital radius around a single proton, what is r_6?
a. $2.5\ r_1$
b. $6.0\ r_1$
c. $12\ r_1$
d. $36\ r_1$

____ 7. What is the orbital radius of an electron in the third energy level of a hydrogen atom?
a. 1.76×10^{-11} m
b. 5.29×10^{-11} m
c. 1.59×10^{-10} m
d. 4.76×10^{-10} m

____ 8. What is the radius of the fourth Bohr orbital in hydrogen?
a. 3.31×10^{-12} m
b. 1.32×10^{-11} m
c. 2.12×10^{-10} m
d. 8.46×10^{-10} m

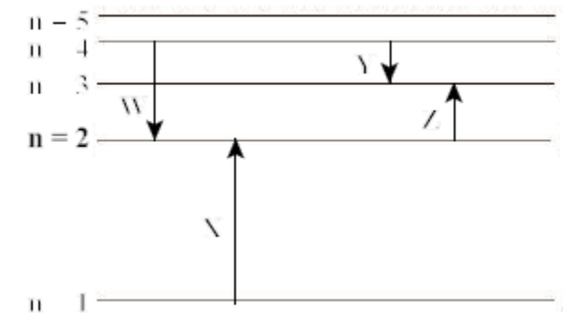
____ 9. If the smallest orbital radius of an electron in a hydrogen atom is $r1$, what is the radius of the third orbit?
a. $1.7\ r_1$
b. $3\ r_1$
c. $6\ r_1$
d. $9\ r_1$

____ 10. The diagram below shows the energy level diagram of a hydrogen atom. The arrows (W, X, Y, Z) indicate transitions of electrons in the atom. Which transition would cause the emission of a photon with the shortest wavelength?



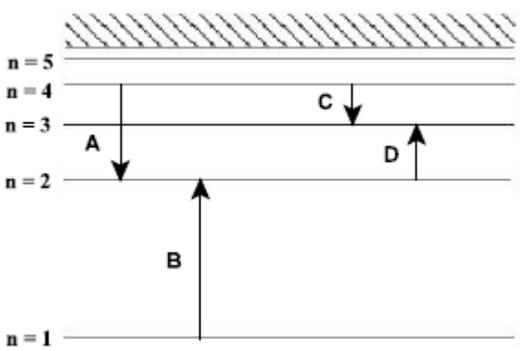
a. W
b. X
c. Y
d. Z

____ 11. The diagram below shows the energy level diagram of a hydrogen atom. The arrows (W, X, Y, Z) indicate transitions of electrons in the atom. Which transition would result from the absorption of a photon with the least amount of energy?



a. W
b. X
c. Y
d. Z

____ 12. The diagram below shows the energy levels of a hydrogen atom where the arrows A, B, C, and D indicate transitions of electrons in the atom. Which transition would result from the emission of a photon with the most energy?

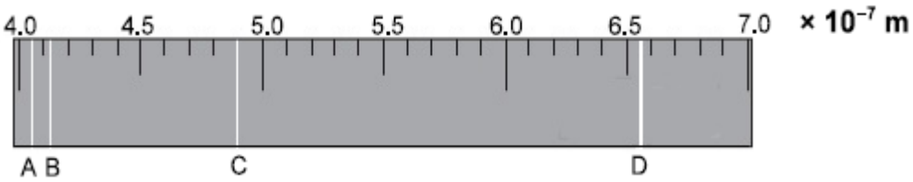


a. A
b. B
c. C
d. D

_____13. Which best explains why each atom in the periodic table has a unique set of spectral lines?

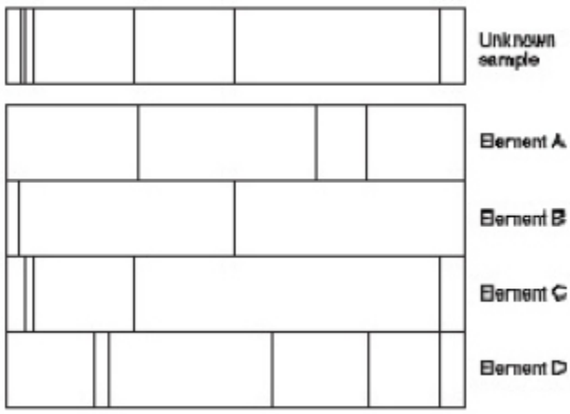
(A) Each atom has a unique neutron to proton ratio.
(B) Each atom has a unique set of energy levels.
(C) The electrons in atoms are in constant motion.
(D) The electrons in atoms orbit the nucleus.

____ 14. The diagram below shows spectral lines for hydrogen when viewed through a spectroscope. Which line corresponds to an electron transition from energy level 3 to energy level 2?



a. A
b. B
c. C
d. D

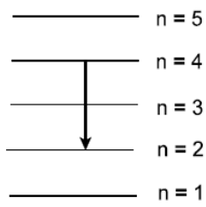
_____15. The diagram below shows the bright line spectra of four elements along with thespectrum of an unknown gaseous sample. Which elements are found in the unknown sample?



(A) A and C
(B) A and D
(C) B and C

Problem

16. The diagram below shows the first five energy levels of an electron orbiting the nucleus of a hydrogen atom. Calculate the wavelength of the emitted photon for the electron transition indicated by the arrow in the diagram.



15. A photon of light is emitted from a hydrogen lamp when an electron falls from the third energy level to the second energy level. Calculate the energy and the wavelength for this photon.

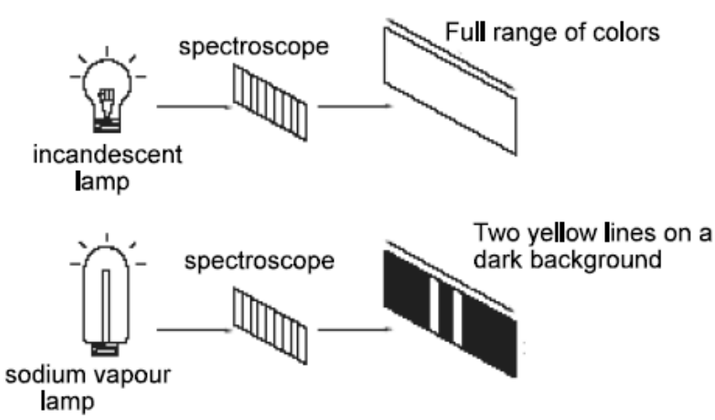
16. A hydrogen atom in the first excited state (n = 2) relaxes to its ground state by emitting a photon. What is the energy of the emitted photon?

17. A hydrogen atom in the first excited state (n =2) absorbs a photon and moves to the second excited state (n =3). What is the frequency of the absorbed photon?

18. Determine the wavelength of the light given off when an electron in hydrogen moves from the n=4 to the n=2 orbit. **(6 marks)**

19. An electron in a hydrogen atom gain 0.966 eV of energy as it jumps from one energy level to another. Calculate what energy level the electron moves to if it starts at energy level 3.

20. The spectra of two light sources through spectroscopes are shown in the diagram below.



a) What type of spectrum is produced in each case?
b) Explain why the observed spectra are different.

The Bohr Atom
Answer Section

MULTIPLE CHOICE

1. ANS: B DIF: ii TOP: Bohr atom KEY: energy levels
2. ANS: D DIF: ii TOP: Bohr atom KEY: Energy of electons
3. ANS: D DIF: ii TOP: Bohr atom KEY: energy levels
4. ANS: B DIF: ii TOP: Bohr atom KEY: energy levels
5. ANS: B DIF: ii TOP: Bohr atom KEY: energy level
6. ANS: C DIF: ii TOP: Bohr atom KEY: orbital radius
7. ANS: D DIF: ii TOP: Bohr atom KEY: orbital radius
8. ANS: D DIF: ii TOP: Bohr atom KEY: radius
9. ANS: D DIF: i TOP: Bohr atom KEY: Energy level
10. ANS: A DIF: iii TOP: Bohr atom KEY: emission of photon
11. ANS: D DIF: iii TOP: Bohr atom KEY: absorption of a photon
12. ANS: A DIF: iii TOP: Bohr atom KEY: Energy levels
13. ANS: D DIF: iii TOP: Bohr atom KEY: enery levels

PROBLEM

14. ANS:

From n = 4 to n = 2

$$\Delta E = E_4 - E_2$$

0.5 marks $$= \frac{-13.6}{4^2} - \frac{-13.6}{2^2}$$

0.5 marks $$= 2.55eV$$

0.5 marks $$2.55\,eV = 4.08x10^{-19}\,J$$

0.5 marks $$E = \frac{hc}{\lambda} \therefore \lambda = \frac{hc}{E} = 487\,nm$$

DIF: ii KEY: Bohr atom MSC: Energy levels

15. ANS:

Answer:

$E_3 = \frac{-13.6eV}{3^2} = -1.51eV$ **0.5 marks**

$E_2 = \frac{-13.6eV}{2^2} = -3.4eV$ **0.5 marks**

$E_{upper} - E_{lower} = -1.51eV - -3.4eV = 1.89eV$ **0.5 marks**

$1.89eV = \frac{hc}{\lambda}$

$\lambda = \frac{hc}{1.89eV} = \frac{(6.626x10^{-34} J \cdot s)(3.00x10^8 m/s)}{3.024x10^{-19} J} = 6.6x10^{-7} m$ **0.5 marks**

DIF: ii TOP: Bohr atom KEY: energy levels

16. ANS:
see key

DIF: ii TOP: Bohr atom KEY: Energy of photon

17. ANS:

$\mathbf{E_{n=2} = \frac{-2.18 \times 10^{-18} J}{(2)^2} = -5.45 \times 10^{-19} J}$

$\mathbf{E_{n=3} = \frac{-2.18 \times 10^{-18} J}{(3)^2} = -2.42 \times 10^{-19} J}$

$\mathbf{E\ \lambda = E_2 - E_3 = -5.45 \times 10^{-19} J - -2.42 \times 10^{-19} J = -3.03 \times 10^{-19} J}$

$\mathbf{f = \frac{E}{h} = \frac{3.03 \times 10^{-19} J}{6.626 \times 10^{-34} J.s} = 4.57 \times 10^{14} Hz}$

DIF: ii TOP: Bohr atom KEY: energy levels

18. ANS:
Solution:

$E_4 = \frac{13.6eV}{n^2} = \frac{13.6eV}{4^2} = 0.85eV$ **(0.5)**

$E_2 = \frac{13.6eV}{n^2} = \frac{13.6eV}{2^2} = 3.4eV$ **(0.5)**

Then,

$hf = E_2 - E_4$

$hf = 3.4eV - 0.85eV = 2.55eV$ **(0.5)**

Then,

$\lambda = \frac{c}{f} = \frac{hc}{\Delta E}$ **(0.5)**

$\lambda = \frac{(6.626x10^{-34} J \cdot s)(3.00x10^8 \frac{m}{s})}{2.55eV}$

$\lambda = \frac{(6.626x10^{-34} J \cdot s)(3.00x10^8 \frac{m}{s})}{4.08x10^{-19} J}$ **(0.5)**

$\lambda = 4.88x10^{-7} m$ **(0.5)**

DIF: ii TOP: Bohr atom KEY: energy levels

19. ANS:
a) What type of spectrum is produced in each case?

incandescent = continuous spectrum **0.5 marks**
Sodium vapour = emission spectrum **0.5 marks**

b) Explain why the observed spectra are different.

The continuous spectrum contains light of all wavelengths. **1.0 mark**
In the emission spectrum light is only created when electrons drop from **1.0 mark**
higher to lower energy levels. Sodium vapour emits only two such wavelengths;
representing two such electron jumps.

DIF: ii TOP: bohr atom KEY: spectra of light