Name: ______________________________ Period: __________

Modern-Energy Levels

1. An electron in a mercury atom drops from energy level i to the ground state by emitting a single photon. This photon has an energy of
   1. 1.56 eV
   2. 8.82 eV
   3. 10.38 eV
   4. 11.94 eV

2. White light passes through a cloud of cool hydrogen gas and is examined with a spectroscope. The dark lines observed on a bright background are caused by
   1. the hydrogen emitting all frequencies in white light
   2. the hydrogen absorbing certain frequencies of the white light
   3. diffraction of the white light
   4. constructive interference

3. The bright-line emission spectrum of an element can best be explained by
   1. electrons transitioning between discrete energy levels in the atoms of that element
   2. protons acting as both particles and waves
   3. electrons being located in the nucleus
   4. protons being dispersed uniformly throughout the atoms of that element

4. Explain why a hydrogen atom in the ground state can absorb a 10.2-electronvolt photon, but can *not* absorb an 11.0-electronvolt photon.

5. Excited hydrogen atoms are all in the $n=3$ state. How many different photon energies could possibly be emitted as these atoms return to the ground state?
   1. 1
   2. 2
   3. 3
   4. 4

6. How much energy is required to move an electron in a mercury atom from the ground state to energy level *h*?
   1. 1.57 eV
   2. 8.81 eV
   3. 10.38 eV
   4. 11.95 eV

Base your answers to questions 7 through 10 on the information below.

An electron in a hydrogen atom drops from the n=3 energy level to the n=2 energy level.

7. What is the energy, in electronvolts, of the emitted photon?

8. What is the energy, in joules, of the emitted photon?

9. Calculate the frequency of the emitted radiation. [Show all work, including the equation and substitution with units.]

10. Calculate the wavelength of the emitted radiation. [Show all work, including the equation and substitution with units.]

11. A hydrogen atom with an electron initially in the n=2 level is excited further until the electron is in the n=4 level. This energy level change occurs because the atom has
    1. absorbed a 0.85-eV photon
    2. emitted a 0.85-eV photon
    3. absorbed a 2.55-eV photon
    4. emitted a 2.55-eV photon

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Modern-Energy Levels

Base your answers to questions 12 through 14 on the information below.

The light of the "alpha line" in the Balmer series of the hydrogen spectrum has a wavelength of 6.58×10^{-7} m.

12. Calculate the energy of an "alpha line" photon in joules. [Show all work, including the equation and substitution with units.]

13. What is the energy of an "alpha line" photon in electronvolts?

14. Using your answer to question 13, explain whether or not this result verifies that the "alpha line" corresponds to a transition from the energy level n=3 to energy level n=2 in a hydrogen atom.

15. An electron in the c level of a mercury atom returns to the ground state. Which photon energy could *not* be emitted by the atom during this process?
    1. 0.22 eV
    2. 4.64 eV
    3. 4.86 eV
    4. 5.43 eV

Base your answers to questions 16 through 18 on the information below.

A photon with a frequency of 5.02×10^{14} hertz is absorbed by an excited hydrogen atom. This causes the electron to be ejected from the atom, forming an ion.

16. Calculate the energy of this photon in joules. [Show all work, including the equation and substitution with units.]

17. Determine the energy of this photon in electronvolts.

18. What is the number of the lowest energy level (closest to the ground state) of a hydrogen atom that contains an electron that would be ejected by the absorption of this photon?

19. A photon having an energy of 9.40 electronvolts strikes a hydrogen atom in the ground state. Why is the photon not absorbed by the hydrogen atom?
    1. The atom's orbital electron is moving too fast.
    2. The photon striking the atom is moving too fast.
    3. The photon's energy is too small.
    4. The photon is being repelled by electrostatic force.

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Modern-Energy Levels

Base your answers on questions 20 through 22 on the information below.

A photon with a frequency of 5.48×10^{14} hertz is emitted when an electron in a mercury atom falls to a lower energy level.

20. Identify the color of light associated with this photon.

21. Calculate the energy of this photon in joules. [Show all work, including the equation and substitution with units.]

22. Determine the energy of this photon in electronvolts.

Base your answers to questions 23 through 25 on the information below.

A photon with a wavelength of 2.29×10^{-7} meter strikes a mercury atom in the ground state.

23. Calculate the energy, in joules, of this photon. [Show all work, including the equation and substitution with units.]

24. Determine the energy, in electronvolts, of this photon.

25. Based on your answer to question 24, state if this photon can be absorbed by the mercury atom. Explain your answer.

Base your answers to questions 26 through 29 on the information below.

As a mercury atom absorbs a photon of energy, an electron in the atom changes from energy level *d* to energy level *e*.

26. Determine the energy of the absorbed photon in electronvolts.

27. Express the energy of the absorbed photon in joules.

28. Calculate the frequency of the absorbed photon. [Show all work, including the equation and substitution with units.]

29. Based on your calculated value of the frequency of the absorbed photon, determine its classification in the electromagnetic spectrum.

30. Which type of photon is emitted when an electron in a hydrogen atom drops from the n=2 to the n=1 energy level?
    1. ultraviolet
    2. visible light
    3. infrared
    4. radio wave

31. An electron in a mercury atom drops from energy level *f* to energy level *c* by emitting a photon having an energy of
    1. 8.20 eV
    2. 5.52 eV
    3. 2.84 eV
    4. 2.68 eV

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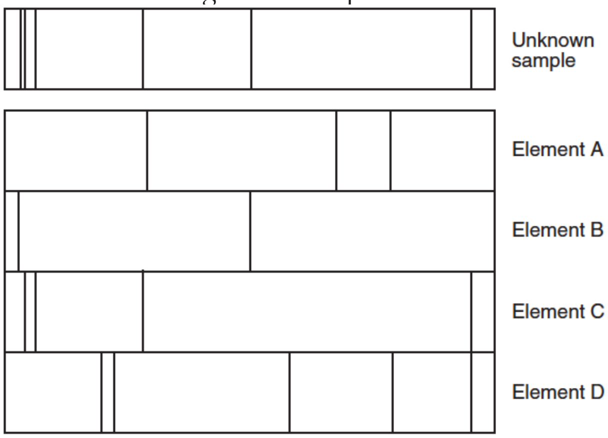
Modern-Energy Levels

32. The diagram below represents the bright-line spectra of four elements, A, B, C, and D, and the spectrum of an unknown gaseous sample.



Based on comparisons of these spectra, which two elements are found in the unknown sample?
1. A and B
2. A and D
3. B and C
4. C and D

33. A mercury atom in the ground state absorbs 20.00 electronvolts of energy and is ionized by losing an electron. How much kinetic energy does this electron have after ionization?
1. 6.40 eV
2. 9.62 eV
3. 10.38 eV
4. 13.60 eV

Base your answers to questions 34 and 35 on the information below.

In a mercury atom, as an electron moves from energy level *i* to energy level *a*, a single photon is emitted.

34. Determine the energy, in electronvolts, of this emitted photon.

35. Determine this photon's energy, in joules.

Base your answers to questions 36 through 39 on the Energy Level Diagram for Hydrogen in the *Reference Tables for Physical Settings/Physics*.

36. Determine the energy, in electronvolts, of a photon emitted by an electron as it moves from the n=6 to n=2 energy level in a hydrogen atom.

37. Convert the energy of the photon to joules.

38. Calculate the frequency of the emitted photon. [Show all work, including the equation and substitution with units.]

39. Is this the only energy and/or frequency that an electron in the n=6 energy level of a hydrogen atom could emit? Explain your answer.

40. Electrons in excited hydrogen atoms are in the n=3 energy level. How many different photon frequencies could be emitted as the atoms return to the ground state?
1. 1
2. 2
3. 3
4. 4

Name: ______________________________ Period: __________

Modern-Energy Levels

Base your answers to questions 41 through 43 on the information below.

Auroras over the polar regions of Earth are caused by collisions between charged particles from the Sun and atoms in Earth's atmosphere. The charged particles give energy to the atoms, exciting them from their lowest available energy level, the ground state, to higher energy levels, excited states. Most atoms return to their ground state within 10 nanoseconds.

In the higher regions of the Earth's atmosphere, where there are fewer interatom collisions, a few of the atoms remain in excited states for longer times. For example, oxygen atoms remain in an excited state for up to 1.0 second. These atoms account for the greenish and red glows of the auroras. As these oxygen atoms return to their ground state, they emit green photons ($f=5.38 \times 10^{14}$ Hz) and red photons ($f=4.76 \times 10^{14}$ Hz). These emissions last long enough to produce the changing aurora phenomenon.

41. What is the order of magnitude of the time, in seconds, that most atoms spend in an excited state?

42. Calculate the energy of a photon, in joules, that accounts for the red glow of the aurora. [Show all work, including the equation and substitution with units.]

43. Explain what is meant by an atom being in its ground state.

44. A photon is emitted as the electron in a hydrogen atom drops from the n=5 energy level directly to the n=3 energy level. What is the energy of the emitted photon?
    1. 0.85 eV
    2. 0.97 eV
    3. 1.51 eV
    4. 2.05 eV

45. Which electron transition between the energy levels of hydrogen causes the emission of a photon of visible light?
    1. n=6 to n=5
    2. n=5 to n=6
    3. n=5 to n=2
    4. n=2 to n=5

46. What is the minimum energy required to ionize a hydrogen atom in the n=3 state?
    1. 0.00 eV
    2. 0.66 eV
    3. 1.51 eV
    4. 12.09 eV

Name: ____________________ Period: __________

Modern-Energy Levels

Base your answers to questions 47 through 50 on the information below and on your knowledge of physics.

An electron in a mercury atom changes from energy level b to a higher energy level when the atom absorbs a single photon with an energy of 3.06 electronvolts.

47. Determine the letter that identifies the energy level to which the electron jumped when the mercury atom absorbed the photon.

48. Determine the energy of the photon, in joules.

49. Calculate the frequency of the photon. [Show all work, including the equation and substitution with units.]

50. Classify the photon as one of the types of electromagnetic radiation listed in the electromagnetic spectrum.