This print-out should have 24 questions. Multiple-choice questions may continue on the next column or page – find all choices before making your selection. The due time is Central time.

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**001** (part 1 of 2) 10 points
The extremes of the x-ray portion of the electromagnetic spectrum range from approximately $5 \times 10^{-9}$ m to $5 \times 10^{-14}$ m.

Find the minimum accelerating voltage required to produce wavelengths at the minimum extreme using electrons. Answer in units of V.

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**002** (part 2 of 2) 10 points
Find the minimum accelerating voltage required to produce wavelengths at the maximum extreme using electrons. Answer in units of V.

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**003** (part 1 of 1) 10 points
How does Rutherford's model of the atom account for the back-scattering of alpha particles directed at the gold leaf?

**1.** There is a dense concentration of positive charge and mass in the nucleus of Rutherford's model of the atom.

**2.** Positive charge and mass of the atom are spread throughout the volume of the atom.

**3.** The positive charges of the atom are spread throughout the volume of the atom.

**4.** Negative charge and mass of the atom are spread throughout the volume of the atom.

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**004** (part 1 of 2) 10 points
The "size" of the atom in Rutherford's model is about $1.5 \times 10^{-10}$ m.

Determine the attractive electrostatics force between a electron and a proton separated by this distance. Answer in units of N.

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**005** (part 2 of 2) 10 points
Determine the electrostatic potential energy of the atom. Answer in units of eV.

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**006** (part 1 of 1) 10 points
In a Rutherford scattering experiment, an $\alpha$-particle (of charge $+2e$) heads directly toward a gold nucleus (of charge $+79e$.) The $\alpha$-particle has a kinetic energy of 9.2 MeV when very far ( $r \to \infty$) from the nucleus.

Assuming the gold nucleus to be fixed in space, determine the distance of closest approach. (Hint : Use conservation of energy.) Answer in units of fm.

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**007** (part 1 of 2) 10 points
Determine the maximum wavelength of the photon that hydrogen in the excited state $n_i = 8$ can absorb. The energy of the ground state of hydrogen is $-13.6$ eV. Answer in units of nm.

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**008** (part 2 of 2) 10 points
What would be the next smaller wavelength that would work? Answer in units of nm.

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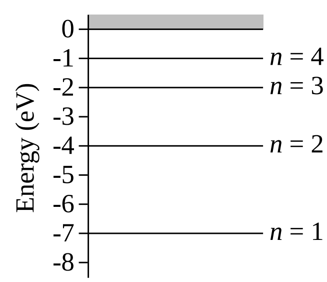
**009** (part 1 of 2) 10 points
A hypothetical atom has four energy states as shown.




Which of the following photon energies $E_\nu$ could NOT be found in the emission spectra of this atom after it has been excited to the $n = 4$ state?

**1.** $E_\nu = 1$ eV

**2.** $E_\nu = 3$ eV

**3.** $E_\nu = 5$ eV

**4.** $E_\nu = 4$ eV

**5.** $E_\nu = 2$ eV

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**010** (part 2 of 2) 10 points

Which of the following transitions will produce the photon with the longest wavelength?

**1.** $n = 3$ to $n = 1$

**2.** $n = 4$ to $n = 3$

**3.** $n = 2$ to $n = 1$

**4.** $n = 4$ to $n = 1$

**5.** $n = 3$ to $n = 2$

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**011** (part 1 of 1) 10 points

In the Bohr model of the atom, the postulate stating that the orbital angular momentum of the electron is quantized can be interpreted in which of the following ways?

**1.** An integral number of electron wavelengths must fit into the electron's circular orbit.

**2.** An incident photon is completely absorbed when it causes an electron to move to a higher energy state.

**3.** An electron has spin of $\frac{1}{2}$.

**4.** Only one electron can exist in each possible electron state.

**5.** The atom is composed of a small, positively charged nucleus orbited by electrons.

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**012** (part 1 of 1) 10 points

Suppose that a hydrogen atom in the ground state absorbs a photon of wavelength 18 nm.

Will the atom be ionized? If so, what will be the kinetic energy of the electron when it gets far away from its atom of origin? Answer in units of eV.

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**013** (part 1 of 1) 10 points

An electron in chromium makes a transition from the $n = 2$ state to the $n = 1$ state without emitting a photon. Instead, the excess energy is transferred to an outer electron in the $n = 4$ state, which is ejected by the atom. (This is called an Auger process, and the ejected electron is referred to as an Auger electron). Use the Bohr theory to find the kinetic energy of the Auger electron. Answer in units of eV.

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**014** (part 1 of 1) 10 points

If the electron in a hydrogen atom obeyed classical mechanics instead of quantum mechanics, would it emit a continuous spectrum or a line spectrum? Explain.

**1.** Classical physics predicts the future of the atomic world.

**2.** It would emit a continuous spectrum. Its energy would change gradually and continuously as it spiraled inward.

**3.** It would emit a line spectrum.

**4.** Classical physics was not based on experiments.

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**015** (part 1 of 2) 10 points

The "size" of the atom in Rutherford's model is about $1.5 \times 10^{-10}$ m.

Determine the speed of an electron moving in a circle about the proton using the attractive electric force between an electron and a proton separated by this distance. Answer in units of m/s.

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**016** (part 2 of 2) 10 points

Compute the de Broglie wavelength of the electron as it moves about the proton. Answer in units of nm.

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**017** (part 1 of 4) 10 points

Determine the longest wavelength in the Lyman series ($n_f = 1$) of hydrogen. Answer in units of nm.

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**018** (part 2 of 4) 10 points

Determine the shortest wavelength in the Lyman series ($n_f = 1$) of hydrogen. Answer in units of nm.

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**019** (part 3 of 4) 10 points

Determine the longest wavelength in the Paschen series ($n_f = 3$) of hydrogen. Answer in units of nm.

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**020** (part 4 of 4) 10 points

Determine the shortest wavelength in the Paschen series ($n_f = 3$). Answer in units of nm.

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**021** (part 1 of 1) 10 points

Two hydrogen atoms, both initially in the ground state, undergo a head-on collision.

If both atoms are to be excited to the $n = 5$ level in this collision, what is the minimum speed each atom can have before the collision? Answer in units of m/s.

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**022** (part 1 of 2) 10 points

When a muon with charge $-e$ is captured by a proton, the resulting bound system forms a "muonic atom", which is the same as hydrogen except with a muon (of mass 207 times the mass of an electron) replacing the electron.

For this "muonic atom", determine the Bohr radius. Answer in units of nm.

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**023** (part 2 of 2) 10 points

Find the energy of the $n = 4$ state. Answer in units of J.

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**024** (part 1 of 1) 10 points

An electron has a de Broglie wavelength equal to the diameter of a hydrogen atom in its ground state.

What is the kinetic energy? Answer in units of eV.