Physics 204, Spring 2007, Final Exam – One page of notes permitted

1. Planck's constant has units
(A) J-s; (B) J/s; (C) J-m; (D) J/m

2. A visible photon has wavelength roughly
(A) 5 μm; (B) 0.5 μm; (C) 5 nm; (D) 0.5 nm

3. An ultraviolet photon may have energy
(A) 5×10^{-3} eV; (B) 0.5 eV; (C) 5 eV; (D) 5 keV

4. An electron with wavelength 0.1 nm has energy
(A) 0.15 eV; (B) 1.5 eV; (C) 15 eV; (D) 150 eV

5. The mass equivalent of the hydrogen atom binding energy, 13.6 eV, which is a correction to the mass of the hydrogen atom in its ground state, is about
(A) 1×10^{-18} kg; (B) 8×10^{-26} kg; (C) 9×10^{-31} kg; (D) 2×10^{-35} kg

6. The ionization energy of hydrogen is 13.6 eV, and this is also the limiting energy of the Lyman series photons (produced in transitions to the ground state of the hydrogen atom). The lowest energy photon in the Lyman series is
(A) 1.7 eV; (B) 3.4 eV; (C) 6.8 eV; (D) 10.2 eV

7. The range of a β particle is the distance it travels through an absorbing material. For a source of β particles of energy E and an absorbing material of mass density ρ, the range should be roughly
(A) proportional to both E and ρ; (B) inversely proportional to E and proportional to ρ; (C) proportional to E and inversely proportional to ρ; (D) inversely proportional to both E and ρ

8. According to the Wien displacement law, the maximum intensity in the blackbody spectrum at temperature T is at wavelength $2.9 \times 10^{-3}/T$ (SI units). This means our own thermal glow peaks at a wavelength closest to
(A) 3 mm; (B) 1 mm; (C) 10 μm; (D) 300 nm

9. If the temperature of the Sun increased by 1%, its power output in the form of sunlight would increase
(A) 1%; (B) 2%; (C) 3%; (D) 4%

10. The quantity $\epsilon_0 h^2/e^2 m_e$ in the usual notation (permittivity, Planck's constant, elementary charge, mass of the electron) is dimensionally
(A) time; (B) length; (C) velocity; (D) energy

The next two questions are based on the following passage:

Ernest Rutherford tried to quantify how radioactive his sources were. In the presence of radioactivity, charged capacitors couldn't hold their charge. The radiation ionized the air between the plates, increasing the electrical conductivity and the leakage current. The rate of discharge by leakage was thus indirectly a measure of radioactivity. Rutherford could sprinkle thorium powder on the bottom plate of a parallel plate capacitor, then measure its effect on the discharge rate. What he found was that there seemed to be two different kinds of radiation, which he named *alpha* and *beta*. Both were ionizing radiations, leading to the discharge effect, but the part he called alpha, which accounted for most of the ionization, was stopped by the thinnest paper, while the part he called beta was more penetrating, and one could see in detail how successive layers of paper over the thorium powder reduced the power of the beta component to ionize the air between the plates.

11. According to the passage, α radiation is stopped by thin paper because
(A) it is less ionizing than β radiation; (B) it is less energetic than β radiation; (C) it is less abundant than β radiation; (D) none of the above

12. Rutherford's method for measuring radioactivity really measures
(A) capacitance; (B) energy; (C) charge; (D) frequency

13. UV light is more hazardous to health than visible light because
(A) it has shorter wavelength; (B) it has longer wavelength; (C) it is more intense; (D) it is at a higher temperature

14. A 10 Ω resistor, a 20 Ω resistor, and a 4 V battery together make a single circuit (all components in series). The voltage drop across the 10 Ω resistor, compared to that across the 20 Ω resistor, is in the proportion
(A) 1:4; (B) 1:2; (C) 1:1; (D) 2:1

15. In the first order diffraction pattern from a grating, just considering the visible light from a white light source, bluer light is scattered at
(A) a larger angle because it is shorter wavelength; (B) a smaller angle because it is shorter wavelength; (C) a larger angle because of Rayleigh scattering; (D) a smaller angle because of Rayleigh scattering.

16. Two flutes should be playing the same note, at 400 Hz, but a beat is heard at 2 Hz. To correct this tuning problem, the higher-pitched flute should be
(A) shortened by 0.5%; (B) shortened by 1%; (C) lengthened by 0.5%; (D) lengthened by 1%

17. A charge $Q = 1\ \mu$C is separated on a 100 nF capacitor. An electron that "falls" from one plate to the other gains energy
(A) 5 μJ; (B) 50 μJ; (C) 500 μJ; (D) 10 eV

18. A thin oil film on water looks colorful in reflected light because

(A) the index of refraction depends on the wavelength; (B) the light reflected from the oil-water interface undergoes a phase change of π; (C) the light reflected from air-oil interface undergoes a phase change of π; (D) the light reflected from the oil-water interface undergoes a phase change that depends on oil thickness

19. A conductor decides that one violinist is not enough for a certain part, so he puts 10 violinists on it, raising the loudness by 10 decibels. Even that is not enough, so he puts 10 more violinists on the part, raising the loudness by an additional

(A) 1 decibel; (B) 3 decibels; (C) 10 decibels; (D) 20 decibels

20. In a certain device, it is necessary to be able to charge a 1 nF capacitor to essentially its full charge in 1 μs. The circuit that does this will need to have

(A) R$<$1000 Ω; (B) R$>$1000 Ω; (C) V$<$1000 volts; (D) V$>$1000 volts.

Short answer questions: write at least two informative paragraphs

1. What was surprising about the concept of photon when it was first suggested? And what evidence led people to accept this surprising idea?

2. Describe the blackbody spectrum, and mention several things that are interesting about it.