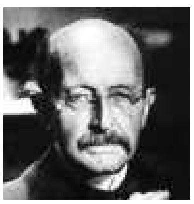
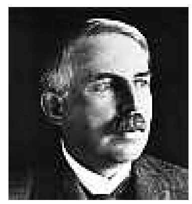
PHYS420 (Spring 2002)
Riq Parra

Exam #2
(Friday, April 12th, 2002)

Exam 2 – Development of Quantum Mechanics

Do NOT write your name on this exam. Write your class ID number on the top right hand corner of each problem page. Do NOT write your class ID number on this page.

Grading breakdown:

Part 1	**18 Multiple choice**	**36 points**
Part 2	**10 Short answer**	**36 points**
	Total points	**72 points**

Part 1 Multiple choice problems (2 points each).

Questions 1 & 2 refer to the following equation: ${}_{13}Al^{27} + {}_{2}He^{4} \rightarrow {}_{15}P^{30} + X + energy$.

1. According to the above nuclear reaction, phosphorous (P) is produced by bombarding aluminum (Al) atoms with what type of atomic particle?

(A) Neutrons.
(B) Riqons.
(C) Alpha particles.
(D) Protons.
(E) Electrons.

2. According to the above nuclear equation, particle X is which atomic particle?

(A) Neutrons.
(B) Riqons.
(C) Alpha particles.
(D) Protons.
(E) Electrons.

Questions 3 - 5 refer to the following list of names.

I. J.J. Thompson
II. H.G.J. Moseley
III. Ernest Rutherford
IV. Marie Curie
V. Niels Bohr

3. This scientist 'discovered' the electron.

(A) I
(B) II
(C) III
(D) IV
(E) V

4. This scientist's model of the atom contained electrons in a uniform, homogenous background of positive charge.

(A) I
(B) II
(C) III
(D) IV
(E) V

5. This scientist theorized that electrons could only be located in 'quantized' energy levels.

(A) I
(B) II
(C) III
(D) IV
(E) V

6. If a particular metal in a photocell releases a current when blue light shines on it, it must also release a current when it is struck with

(A) Ultraviolet light.
(B) Infrared light.
(C) Microwaves.
(D) Radio waves.
(E) Red light.

7. A particle was ejected from the nucleus of an atom in a radioactive decay and the atomic number of the atom increased. The particle was probably

(A) a hydrogen nuclei
(B) a neutron
(C) a proton
(D) an alpha particle
(E) a beta particle

8. When uranium 235 undergoes fission according to the following reaction $_{92}U^{235} + _0n^1 \rightarrow _{56}Ba^{141} + X + 3\ _0n^1$, the X stands for

(A) $_{51}Sb^{92}$
(B) $_{51}Sb^{43}$
(C) $_{36}Kr^{90}$
(D) $_{36}Kr^{92}$
(E) $_{55}Ba^{145}$

9. The laws of photoelectric emission

(A) are explained by Maxwell's theory of light.
(B) state that emission is inversely proportional to the intensity of the incident light.
(C) state that increasing the intensity of the incident light increases the kinetic energy of the photoelectrons.
(D) state that increasing the frequency of the incident light increases the kinetic energy of the photoelectrons.
(E) state that the maximum energy to release the electron from a surface is the work function.

10. A blackbody radiator

(A) does not absorb thermal radiation.
(B) is a perfectly reflecting surface.
(C) is used in newer automobile engines.
(D) emits radiation only in the visible light region.
(E) none of the above.

11. A nuclide with a half-life of 2 days is tested after 6 days. What fraction of the sample *has decayed*?

(A) 1/8
(B) 1/4
(C) 1/2
(D) 3/4
(E) 7/8

12. Several classical models were proposed to explain the observed blackbody's spectral emittance. In one particular derivation it was found that it diverged at short wavelengths. This result is known as

(A) Stefan's law.
(B) the ultraviolet catastrophe.
(C) the Compton effect.
(D) Wien's law.

13. In the Compton experiment, the wavelength of the scattered light is _______ the wavelength of the incident light.

(A) longer than
(B) the same as
(C) shorter than

14. Which quantity(ies) is(are) quantized in the Bohr atom?

(A) the electron orbit.
(B) the electron energy.
(C) the electron angular momentum.
(D) all of the above.
(E) two of the above.

15. In the Bohr atom, the laws of classical mechanics apply to

(A) the orbital motion of the electron in a stationary state.
(B) the motion of the electron during transitions between stationary states.
(C) both of the above.
(D) neither of the above.

16. A beam of ultraviolet light is incident on a metal disk electrically isolated from the environment. Which statement(s) is(are) true?

(A) If the metal disk was initially positively charged, it discharges.
(B) If the metal disk was initially negatively charged, it discharges.
(C) Both of the above.
(D) Neither of the above.

17. A xenon arc lamp is covered with an interference filter that only transmits light of 400 nm wavelength. When the transmitted light strikes a metal surface, a stream of electrons emerges from the metal. If the intensity of the light striking the surface is doubled,

(A) more electrons are emitted in a given time interval.
(B) the electrons that are emitted are more energetic.
(C) both of the above.
(D) neither of the above.

18. In order for an atom to emit light, it must first be ionized. This statement is

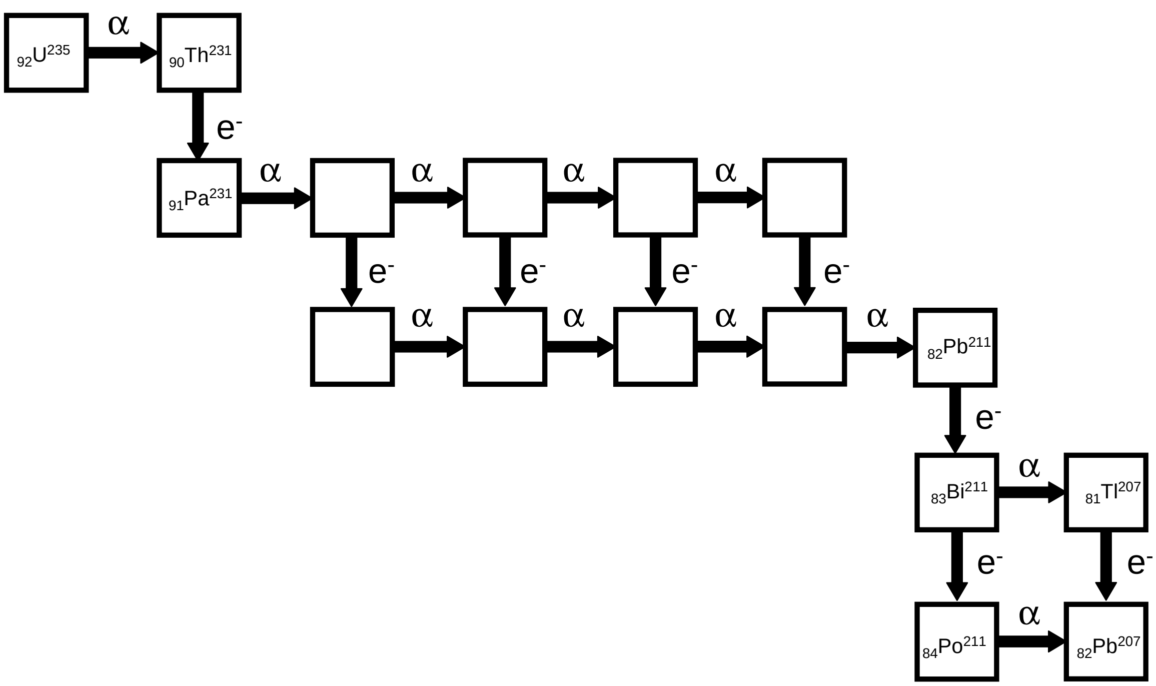
(A) true
(B) false

Part 2 Short answer and computational problems.

1. (2 points) **State two experimental features of line emission spectra.**

2. (2 points) **State two experimental features of blackbody emission spectra.**

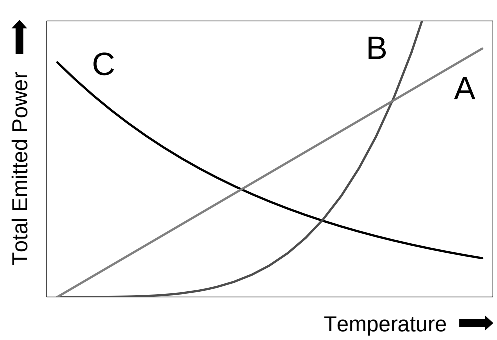
3. (4 points) **In the Actinium series, $_{92}U^{235}$ naturally decays into the stable isotope $_{82}Pb^{207}$. Enter the correct isotope symbol in each open square.**



4. (3 points) **Consider an ideal blackbody at T_0. Increasing the temperature by a factor of 2 does what to the frequency of the peak emission? Show all of steps.**

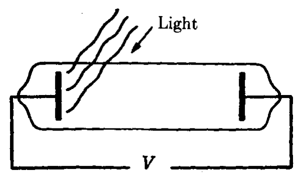
5. (3 points) **Supposed that we have a Carbon atom (Z = 6) that has had all of its orbiting electrons removed except one. Do you expect the first Bohr orbit to be larger or smaller than it was in a hydrogen atom? By what factor? Explain physically why you would expect this to be so?**

6. (3 points) **Consider the following schematic plot of the *total* power per unit area, emitted at all frequencies, as a function of temperature. Which one of these three curves corresponds to a blackbody? Explain your reasoning. *Both axes are linear scales.***

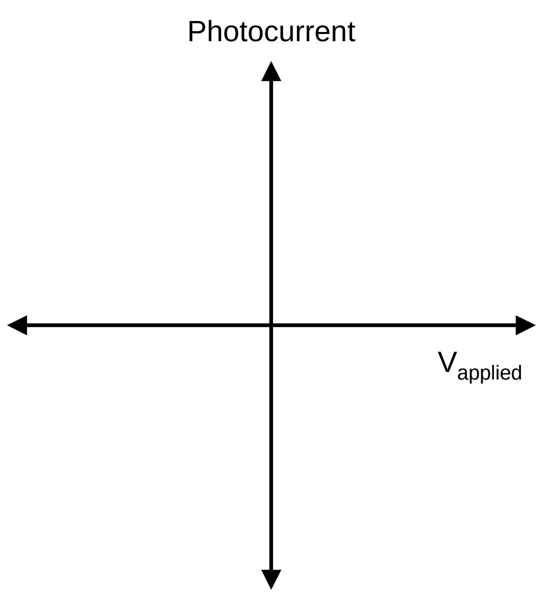


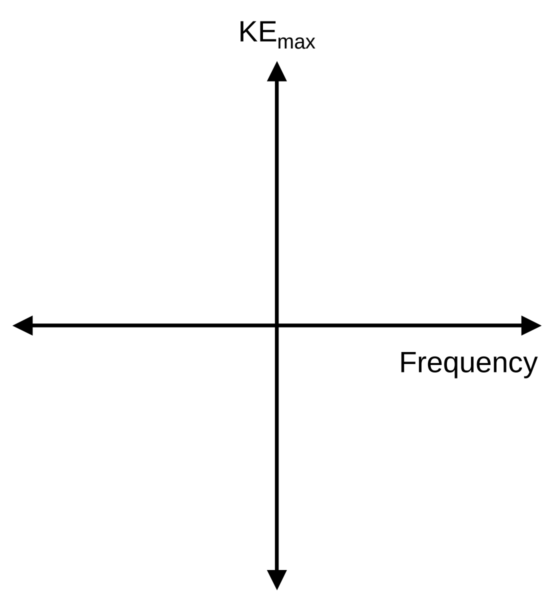
7. (3 points) **Consider the following set of atoms / ions: H^{+}, He^{2+}, Li^{2+}, Be^{5+}, B. To which ones can we apply Bohr's quantized energy formula? Explain your reasoning.**

8. (8 points) **Consider two light beams of different intensities (I_1 and I_2 such that $I_2 > I_1$) incident on the photoelectric circuit shown.**

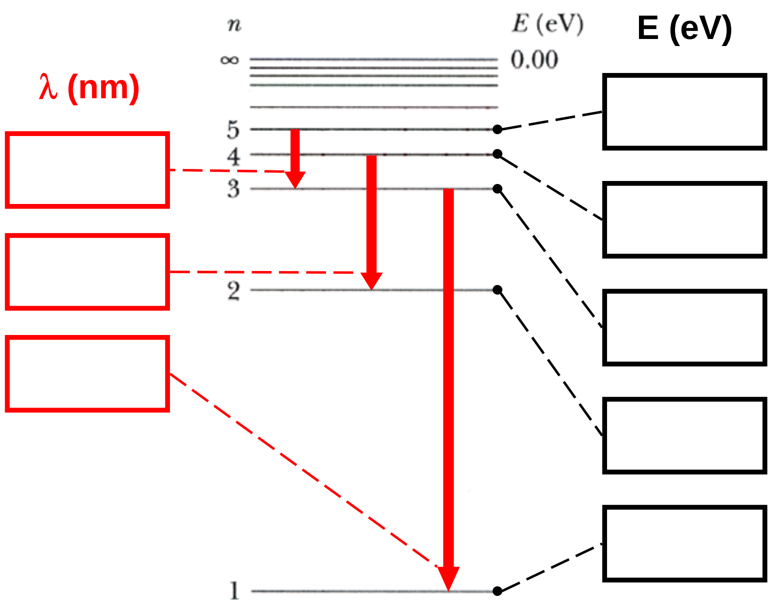


Plot schematically, on the given blank graphs, (1) the photocurrent (i.e. number of ejected electrons per unit time) as a function of applied voltage and (2) the maximum kinetic energy of the photoelectrons as a function of frequency for each beam. Label as many features as you can.





9. (4 points) **Consider the energy level diagram below to be for hydrogen-like Helium (i.e. He^+). Work out the energy of the given levels (in eV) and the wavelengths of the given transitions (in nm).**



10. (4 points) **State an experimental effect (don't just name experiments) that illustrates the following features of light and matter.**

**** Example****
Experimental effect illustrating a prediction of special relativity:

The right way to answer: *the speed of light in vacuum is the same in all directions.*
The wrong way to answer: *the Michelson – Morley experiment.*

(A) the wave nature of light.

(B) the particle nature of light.

(C) the particle nature of an electron.

(D) **the wave nature of an electron.**