Exam 2
- Take exam in Grant Bldg. starting Friday, 13th, through Monday, 16th (by 4:00 pm).
- No late fee associated with Monday, before 4:00.
- Allow at least 1 hour for exam.
  - Be aware of Testing Center hours!
  - If you have special needs see me. Can use a language dictionary.

Study Question
A single electron is sent toward a pair of very closely spaced slits. Then, a great many electrons are sent one at a time through the same device.

a. Describe the pattern produced on the detector screen:
   - by the single electron
     - single dot
   - by the many electrons
     - interference pattern
b. Name and state the fundamental principle that can account for what is observed.
The wave - particle duality of matter:
  - Electrons (or photons) arrive or are observed in lumps or particles, but the probability of arrival of these lumps is determined as the intensity of waves would be.

study question continued

The probability of an electron being observed at the screen is calculated by representing the electron as a probability wave and calculating the interference pattern at the screen.

Where the probability waves give constructive interference the probability is high that an electron will be observed. When electrons are observed at the screen, each one is seen at a point. The single electron is likely to arrive where constructive interference was calculated to occur. By the time many electrons have been observed the interference pattern would be seen. The electrons are seen at points but contribute to form a probability wave pattern.

Conclusion
The conclusion to be drawn from the electron experiment is that electrons, like photons, arrive in lumps, like particles, but the probability of arrival of these lumps is determined as the intensity of waves would be. Electrons have both a wave and a particle aspect to their nature.

Question
P1: A container filled with air (fixed volume) is heated up. What happens?
   a) The pressure decreases because the air molecules expand and hit the container walls more softly.
   b) The pressure stays the same because the number of air molecules and their mass have not changed.
   c) The pressure increases because the air molecules move faster and hit the walls of the container more often.
   d) The pressure decreases because the air molecules spend less time near the container walls.
   e) The pressure stays the same because the air molecules move faster but are softer, so the effects cancel.

Question
What is the nature of gas molecules in the molecular model of matter?
   a) continuous compressible matter
   b) particles that expand and contract with temperature
   c) particles that nearly touch to fill the container and only move a little
   d) particles in rapid random motion that collide with one another and the container walls
   e) particles that sit on the bottom of the container when cold, and bounce up when heated
Question

As the temperature of a non-charged gas (not a plasma) in a container increases, which of the following is increasing?
(a) conductivity of the gas
(b) electrical potential energy in the chemical bonds of the gas molecules
(c) average molecular kinetic energy of the gas molecules
(d) average size of the gas molecules
(e) a and c

Question

The charge on the individual electron was measured by
(a) the electron microscope.
(b) the Rutherford experiment.
(c) the oil drop experiment.
(d) gas discharge tube experiments.
(e) the mass spectrometer.

Question

If a single electron passes through a single narrow opening and is then stopped by a screen, what pattern will result?
(I) line about the size of the slit
(II) line broader than the slit

P2: If many electrons pass through a single narrow opening, what pattern will result? What about a double slit?
(I) line about the size of the slit
(II) line broader than the slit

Question

The Rutherford experiment showed
(a) that the atom has a dense, positively charged core.
(b) that electrons radiate and fall into the nucleus.
(c) that the atom is largely empty space.
(d) two of the above.
(e) None of the above.

Question

What experiment shows that light has wave properties?
(a) photoelectric effect
(b) splotches of light in low intensity photographs
(c) the Millikan Oil Drop experiment
(d) interference patterns
(e) b and d
Question

- Mass Spectrometer
- **P3:** Which blip corresponds to the greatest mass?

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<table>
<thead>
<tr>
<th>a</th>
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<th>c</th>
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time

number of particles

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Question

**P4:** You have a mixture of neon, with a mass of 20 amu, and helium, with a mass of 4 amu. At any given temperature, how does the behavior of the two types of molecules (atoms) compare?

- (a) The average speed and average kinetic energy of the molecules is the same.
- (b) The average speed of the neon molecules is higher, but the average K.E. is the same.
- (c) The average speed of the helium molecules is higher, but the average K.E. is the same.
- (d) The average speed of the two is the same, but the average K.E. of the neon is higher.
- (e) The average speed of the two is the same, but the average K.E. of the helium is higher.

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Question

As electrons fill the various shells and their orbitals in forming more and more complex atoms, which orbitals are filled first?

- (a) s first, then d, then p.
- (b) p first, then s, then d.
- (c) d first, then s, then p.
- (d) s first, then p, then d.
- (e) d first, then p, then s.

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Question

**P5:** You place a kettle on a fire to heat cold water. Explain the heat transfer processes that take place so the hot fire heats the kettle and the water.

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Question

The distance labeled with the arrow on the picture is called

- (a) the amplitude
- (b) the frequency
- (c) the period
- (d) the speed
- (e) the wavelength

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Question

Light of a continuous spectrum of visible colors passes through a gas. What type of spectrum do we observe when we look back at the light which passed through the gas?

- (1) continuous
- (2) continuous except for some black lines
- (3) continuous except for some colored lines
- (4) a discrete spectrum of colored lines
Question

P6: At point B, two valleys overlap. What is happening there?
(a) reflection
(b) refraction
(c) diffraction
(d) constructive interference
(e) destructive interference

Question

Light from a laser shines on a pair of closely spaced slits and then falls on a screen. If the light is made extremely dim, what happens to the pattern produced?
(a) The pattern gets dimmer.
(b) The pattern gets fuzzier.
(c) The pattern gets narrower.
(d) The pattern gets speckled, like it is made up of dots.
(e) a and b

Question

The density of a material is defined as:
(a) the ratio of volume to mass.
(b) the specific gravity per unit volume.
(c) mass per unit volume.
(d) buoyant force.
(e) volume divided by its weight.

Question

Why does the light in gas discharge tubes appear to be a collection of lines when viewed in a diffraction grating?
What kinds of particles collect at the two ends of the tube?

Question

P7: What model of the atom was developed as a result of gas discharge tube experiments?
(a) wave model
(b) Thomson or “plum pudding” model
(c) Rutherford or “solar system” model
(d) Bohr or “modified solar system” model
(e) molecular model

Question

Which of these photons has the lowest energy?
(a) radio wave.
(b) gamma wave.
(c) ultraviolet ray.
(d) red visible light.
(e) blue visible light.
Question

In single slit diffraction of an electron, Henry makes the slit narrower to know exactly where the electron is. What else will happen?
What principle explains these results? How does it apply?

Question

Why was Rutherford’s “solar system” model of the atom inadequate to explain discrete emission spectra? (The Rutherford model had more than one shortcoming. What specifically was the problem with discrete spectra?)
(a) Because electrons were considered particles.
(b) Because most of the atom was empty space.
(c) Because electrons were allowed to have any energy.
(d) Because electrons would fall into the nucleus.
(e) Because the light would be absorbed by the atoms rather than be emitted.

Question

What model of the atom was developed that first explained discrete emission spectra?

Question

P8: A difference between microwaves and x-rays is that
(a) microwaves have more energy.
(b) microwaves are particles, whereas x-rays are waves.
(c) x-rays have a higher speed.
(d) microwaves have a longer wavelength.
(e) x-rays have a smaller frequency.

Question

The light observed in a discrete spectrum is emitted when an electron in an atom
(a) "jumps" from one energy level up to a higher energy level.
(b) "jumps" from one energy level down to a lower energy level.
(c) is completely removed from the atom.
(d) is converted to the pure energy of a photon.
(e) b and d.

Question

Wave frequency determines
(a) pitch in sound.
(b) loudness in sound.
(c) color in light.
(d) brightness in light.
(e) a and c.
Question

Which experiments give direct evidence for the idea that all atoms are made of charged particles?

a) beams of particles derived from gases conducting electrical currents
b) the Millikan Oil Drop experiment
c) Rutherford scattering
d) the photoelectric effect
e) two-slit electron interference patterns

Question

Temperature is a measure of

(a) average potential energy of the molecules of a substance.
(b) average kinetic energy of the molecules of a substance.
(c) disorder.
(d) total internal energy in a substance.
(e) ionization energy of an element.

Question

P9: If we examine an object by shining light on it, we see the best detail if

a) wave diffraction is present
b) the wavelength is much larger than the object
c) the wavelength is much shorter than the object
d) the wave is absorbed by the object
e) the wavelength is about the same size as the object

Question

The bending of a stick partially submerged in water is caused by light wave

a) refraction
b) interference
c) diffraction
d) polarization
e) reflection

Question

A baseball behaves as a particle, not a wave, because it has a large

(a) speed.
(b) temperature.
(c) wavelength.
(d) mass.
(e) electric charge.

Question

States of electrons in atoms are uniquely characterized by certain features. Which of the following is not a characteristic feature of a state?

(a) Its shell.
(b) The path of motion of the electron.
(c) The spin of the electron (up or down).
(d) The type of orbital.
(e) The energy of the electron in the state.
**Question**

The maximum number of electrons found in p-orbitals in a given shell is
(a) 2  
(b) 6  
(c) 8  
(d) 10  
(e) 18

**Question**

The molecular model of matter explains all but which one of these?
(a) increase of pressure as temperature increases  
(b) conduction  
(c) evaporation  
(d) formation of atomic spectra  
(e) Brownian motion

**Question**

Quantum mechanics is essential for describing the physical behavior of
(a) Large objects like planets and comets.  
(b) Very small objects like biological cells.  
(c) Extremely small objects like electrons and protons.  
(d) Common objects like airplanes and footballs...  
(e) Small objects like bullets and dust particles.

**Question**

Consider the series of 2-slit experiments described in class. Which of the following five statements is False?
(a) The machine gun event involved real particles (bullets) that traveled through the slits (one or the other) and were observed to arrive at different places along a line behind the slits. A probability curve summarized the average number of bullets expected at any point along the line.  
(b) The water wave event involved real waves that traveled through the slits, diffracted, and the intensity of the waves was observed at different places along a line beyond the slits. The intensity curve showed the interference effect of the two sets of waves traveling through the same region.  
(c) After a great many electrons had been fired through double slits, the pattern observed on a screen placed beyond the slits looked like an interference pattern, but was actually a probability pattern because each individual electron was observed at a point.  
(d) Each electron formed an interference pattern because as the electron passed through the slits it actually spread out in size like waves. The two parts of the wave in the same region caused an interference pattern to form. The intensity of the added waves was observed at different points along a line beyond the slits.  
(e) The conclusion to be drawn from the electron experiment is that electrons, like photons, arrive in lumps, like particles, but the probability of arrival of these lumps is determined as the intensity of waves would be. Electrons have both a wave and a particle aspect to their nature.

**Hey! Good luck! Be ready for reading quiz on Thursday.**