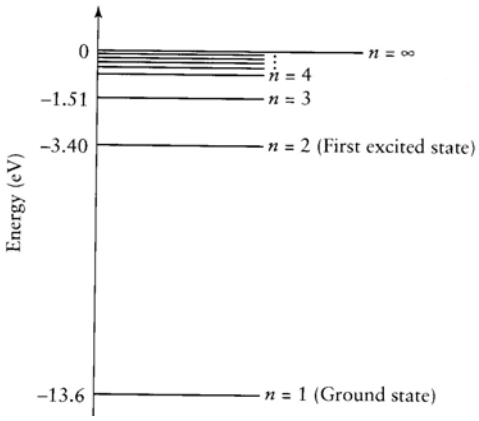
PHYS 102--Concepts of Physics II, University of Virginia
Midterm Exam, March 22nd, 2006

Helpful information: Average atmospheric pressure reading = 760 mm Hg. Acceleration due to gravity near surface of Earth is 9.8 m/s^2 = 32 ft/s^2 = 22 mph/s. There are 1609.3 meters per mile. 1 food calorie = 4186 joules. There are 3.28 feet in one meter. The speed of light is 3×10^8 m/s. Planck's constant h = 6.6×10^{-34} Joule-seconds. 1 eV = 1.6×10^{-19} Joules. Mass of electron = 9.1×10^{-31} kg.

Energy levels for hydrogen



Make sure you have **23** questions.

This is a multiple choice test. Pick the one best answer for each problem.

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1. A seesaw is built with a uniform plank of length 3 meters and mass 20 kg, but the pivot underneath can be moved. If a 45 kg child sits on the left end, and an 8 kg child sits on the right end, where must the pivot be located, as measured from the left end, so that the seesaw balances?

(a) 0.74 meters from the left end
(b) 0.89 meters from the left end
(c) 0.99 meters from the left end
(d) 1.26 meters from the left end
(e) 1.76 meters from the left end

2. When it's orbiting the Earth, astronauts inside the Space Shuttle feel weightless because

(a) there is no net force on them
(b) they are in freefall
(c) the gravitational force from the Earth is zero
(d) the engines maintain a very small thrust during orbit, in a direction towards the Earth
(e) the engines maintain a very small thrust during orbit, in a direction away from the Earth

3. Which one of the following was neither shown nor discussed in class?

(a) the reason ones ears pop when travelling by airplane
(b) cars driving up a ramp attached to a moving truck
(c) how to avoid a car crash when making a left turn
(d) igniting a Virginia Tech banner with a bright green laser
(e) a hologram of a magnifying glass and a pocket watch

4. The ceiling of an arena is 20 meters above the floor. What is the minimum speed that a thrown ball must have in order to reach the ceiling?

(a) 12.1 m/s
(b) 14.9 m/s
(c) 19.8 m/s
(d) 22.3 m/s
(e) 27.7 m/s

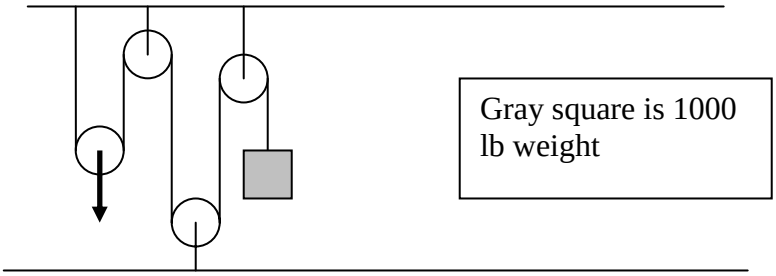
5. In class we used a vacuum pump attached to a large, clear plastic dome. We placed several objects inside the dome, including shaving cream and an inflated balloon (which expanded and popped). During these experiments (for example, while the balloon was expanding), what happened to the plastic dome?

(a) it expanded, because the pressure inside the dome was greater than the pressure outside
(b) it expanded, because the pressure inside the dome was smaller than the pressure outside
(c) it remained perfectly intact, because the pressures inside and outside the dome were equal
(d) it remained perfectly intact, because it was strong enough to withstand a larger pressure outside than inside
(e) it was crushed each time, due to the large outside pressure; that's why spares were always brought in during each lecture

6. "Sublimation" occurs when

(a) Nitrogen gas is cooled to liquid nitrogen
(b) A substance goes directly from solid phase to gas phase
(c) Liquid nitrogen shrinks a helium balloon
(d) A sub-atomic particle is animated by computer
(e) A sub-atomic particle is animated by hand-drawings

7. Using the pulley system below, what downward force (denoted by the arrow) must be exerted on the left-most pulley in order to lift the 1000-lb weight at constant speed?



(a) 250 lbs
(b) 500 lbs
(c) 1000 lbs
(d) 2000 lbs
(e) 4000 lbs

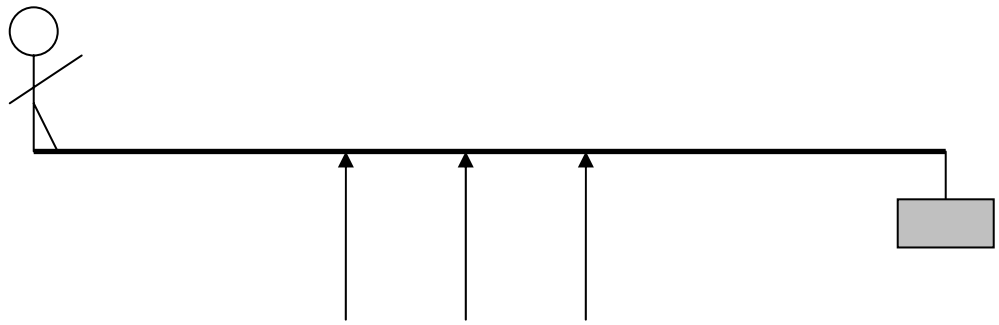
8. This a question about the human biceps muscle. Imagine that you hold your arm so that the upper arm bone (closer to the shoulder) is vertical, and the lower arm bone is horizontal—thus there is a 90-degree angle at your elbow. If you hold a 50-pound weight in your hand, your biceps must exert a force of about

(a) 350 pounds, and your hand can move faster than your biceps can contract
(b) 350 pounds, and your hand moves slower than your biceps can contract
(c) 8 pounds, and your hand can move faster than your biceps can contract
(d) 8 pounds, and your hand moves slower than your biceps can contract
(e) also 50 pounds, and your hand moves at exactly the same speed that the biceps contract

9. While performing a photoelectric effect experiment, it is found that using light of a certain color does successfully eject electrons from the metal. Which one of the following changes, if implemented, <u>might</u> cause the experiment to fail?

(a) doubling the intensity of the light
(b) decreasing the intensity of the light to half the original value
(c) doubling the frequency of the light waves used
(d) halving the frequency of the light waves used

10. As shown in the drawing, a 60-lb plank rests on top of, but is not connected to, three supports. The plank is 8 feet long, with the center directly over the middle support. The spacing between the supports is 1 foot, and the weight on the right end is 40 lbs. If the child weighs 30 lbs, and begins walking from the left end, how far can he walk before the plank will tip?



(a) 1 foot
(b) 2 feet
(c) 3 feet
(d) 5 feet
(e) he can walk all the way to the right end and the plank will not tip

11. According to your textbook, as the temperature of a "blackbody" is increased, the peak of the intensity-versus-wavelength curve shifts to _____ wavelengths, and to explain it Max Planck proposed that the energies of the oscillating atoms are _____.

(a) shorter, continuous
(b) shorter, quantized
(c) longer, continuous
(d) longer, quantized

12. A particular hydrogen atom has its electron in the n = 3 state. What must be the minimum frequency of a photon that will ionize the atom from this level?

(a) 3.66×10^{14} Hz
(b) 4.66×10^{14} Hz
(c) 5.66×10^{14} Hz
(d) 6.66×10^{14} Hz
(e) 7.66×10^{14} Hz

13. In class we compared the vision of the students to the theoretical limitation by using

(a) an eye chart hung from the entrance door
(b) blue lines drawn on white paper
(c) a very dim orange light bulb swinging like a pendulum
(d) a row of 10 pencils held in place by Styrofoam
(e) a thin black string and a thin white string, each hung from the catwalk

14. Regarding a person whose blood pressure has been measured to be “120 over 80”, which of the following is NOT true?

(a) the gauge pressure is 120 when the heart is contracting
(b) the gauge pressure is smallest when the heart is resting
(c) the blood pressure drops below atmospheric pressure for about half the contract/rest cycle
(d) the stated pressure is true only at the level of the heart; it will be lower in the head
(e) the numbers refer to a standard based on millimeters of mercury

15. In the context of lasers, forcing the majority of atoms into excited states is called

(a) spontaneous excitation
(b) spontaneous emission
(c) stimulated emission
(d) the Bose-Einstein condition
(e) population inversion

16. Consider an ordinary rubber balloon inflated with air. If you freeze the balloon with liquid nitrogen, it will shrink to a very small size. Now you place the balloon on a sensitive weight scale. As the balloon warms up, it will re-expand and the scale reading will

(a) decrease, because the mass of the balloon is decreasing
(b) increase, because the mass of the balloon is increasing
(c) decrease, because the buoyancy force on the balloon is increasing
(d) decrease, because the buoyancy force on the balloon is decreasing
(e) increase, because the buoyancy force on the balloon is decreasing

17. Which one of the following is NOT true regarding lasers?

(a) The “a” in the word laser stands for “amplification”.
(b) The new high-definition DVD players will use laser light of a longer wavelength than current ones.
(c) During the stimulated-emission process, the emitted photon travels in the same direction as the stimulating photon.
(d) If an atom inside a laser absorbs a photon, that atom might later exhibit spontaneous emission.

18. Your body is approximately 20% efficient at converting food calories into useful work. Use this number to solve the following problem. You wish to burn off the 280 food calories in TWIX bar by climbing stairs. If each step is 25-centimeters high, and your mass is 70 kilograms, how many steps must you climb (pick the closest number)?

(a) 113 steps
(b) 273 steps
(c) 840 steps
(d) 1367 steps
(e) 6835 steps

19. The “diffraction gratings” we used to observe light emanating from various atoms changed the _____ of the light based on _____.

(a) speed; its intensity
(b) speed; its phase
(c) direction; its color
(d) direction; its intensity
(e) phase; whether it was from stimulated or spontaneous emission

20. A 45-kg person stands on an ice rink (so that friction is negligible) and horizontally throws tennis balls at the rate of five per second, at a speed of 30 m/s. If each ball has a mass of 60 grams, what will be the initial acceleration of the person? Make the approximation that the tennis balls cause a negligible change to the person’s mass.

(a) 0.2 m/s^2
(b) 1.3 m/s^2
(c) 1.5 m/s^2
(d) 2.2 m/s^2
(e) 2.5 m/s^2

21. The reason electrons in atoms are only allowed certain orbits is that

(a) Their electrical attraction towards the nucleus decreases in a discontinuous way
(b) An integral number of their wavelengths must fit around the orbit
(c) The protons are competing for the orbits also, and fill up some of them
(d) The neutrons are competing for the orbits also, and fill up some of them
(e) Radio waves from our surroundings interfere with the electron waves

22. A beam of which (one or more) of the following will be deflected by a magnet: electrons, protons, neutrons, photons?

(a) photons only
(b) electrons only
(c) electrons and protons only
(d) photons and neutrons only
(e) neutrons only

23. (extra credit—can be used to replace one missed question, but not to increase score above 100%)

The first successful optical laser utilized which of the following precious gems?

(a) diamond
(b) ruby
(c) sapphire
(d) emerald
(e) amethyst

End of exam.