

Name (printed) _____

Name (signature as on ID) _____

Lab Section _____

Exam IV Chaps. 26, 28, 29 in Young/Geller

Note: The speed of light in air is $c = 3.00 \times 10^8$ m/s.

1 eV = 1.60×10^{-19} J

Multiple choice questions. Circle the correct answer. No work need be shown and no partial credit will be given.

(6 pts) 1. Audio speakers *A* and *B* are connected to the same amplifier and produce sound waves that are emitted in phase. Each speaker emits waves with wavelength λ . Speaker *B* is 6.5 m to the right of speaker *A*. A person is standing at point *P*, which is 7.5 m to the right of speaker *B*. What is the largest value of λ for which destructive interference occurs at point *P*?



- (a) 2 m
- (b) 4 m
- (c) 6.5 m
- (d) 7.5 m
- e (e) 13 m
- (f) 15 m
- (g) 26 m
- (h) 30 m
- (i) none of the above

(6 pts) 2. You illuminate two very narrow slits in air by monochromatic coherent light and find that the first interference maximum on either side of the central bright spot is at an angle of $\pm 12.0^\circ$ from the center of the central bright spot. You then immerse the entire apparatus in a transparent liquid and find that the first maximum on either side of the central bright spot occurs instead at $\pm 9.0^\circ$. What is the index of refraction of the liquid?

- (a) 0.5
- b (b) 1.3
- (c) 1.5
- (d) 2.0
- (e) 3.0
- (f) 4.0
- (g) none of the above

(6 pts) 3. A single slit that has a width of 0.40 mm is illuminated by coherent light of wavelength 500 nm. The diffraction pattern is observed on a screen that is a large distance from the slit. On the screen the width of the central maximum is 4.0 mm. If the width of the slit is changed to 0.20 mm, the width of the central maximum becomes

- (a) 4.0 mm (unchanged)
- (b) 2.0 mm
- (c) 8.0 mm
- (d) none of these

(5 pts) 4. When a photon of light scatters off of a free electron that is initially stationary, the wavelength of the photon

- (a) remains the same
- (b) decreases
- (c) increases

(5 pts) 5. The number of $3d$ states (the number of distinct sets of quantum numbers) for hydrogen is

- (a) 32
- (b) 18
- (c) 14
- (d) 10
- (e) 8
- (f) 5
- (g) 4
- (h) 2
- (i) none of the above

(6 pts) 6. For a hydrogen atom in the $3p$ state, what is the value of the smallest possible angle between the angular momentum vector and the z -axis?

- (a) 90°
- (b) 45°
- (c) 35°
- (d) zero
- (e) none of the above

Show all your work. Partial credit will be given if earned. Write your answers in the blanks provided.

(14 pts) 7. A telescope has a primary mirror that is 4.0 m in diameter. What is the closest two objects can be on the surface of Mars and still be resolved when using this telescope? Assume Mars is 7.9×10^{10} m from the earth and assume a wavelength of 500 nm. Assume the resolution is diffraction limited and use Rayleigh's criterion.

Ans. 12,050 m

(17 pts) 8. When light of wavelength $\lambda = 400$ nm shines on a certain metal surface, the maximum kinetic energy of the photoelectrons is 0.8 eV. What is the maximum kinetic energy of the photoelectrons produced when light of wavelength $\lambda = 200$ nm shines on the same surface?

Ans. 3.9 eV

(9 pts) 9. A photon has energy 6.0 eV. What is the magnitude of the momentum of this photon?

Ans. $3.2 \times 10^{-27} \text{ kg}\cdot\text{m/s}$

(9 pts) 10. An atom undergoes a transition from a state of energy 8.0 eV to a state of 3.0 eV. What is the wavelength of the photon emitted by the atom?

Ans. 248 nm

(17 pts) 11. A thin horizontal film of thickness t and refractive index 1.5 has air on either side of the film. Light of wavelength 600 nm in air is incident normally on the upper surface of the film. What is the minimum nonzero thickness of the film for which there will be destructive interference between the light reflected at the upper and lower surfaces of the film?

Ans. 200 nm