Chapter 36: DIFFRACTION

1. Sound differs from light in that sound:
   A. is not subject to diffraction
   B. is a torsional wave rather than a longitudinal wave
   C. does not require energy for its origin
   D. is a longitudinal wave rather than a transverse wave
   E. is always monochromatic

   ans: D

2. Radio waves are readily diffracted around buildings whereas light waves are negligibly diffracted around buildings. This is because radio waves:
   A. are plane polarized
   B. have much longer wavelengths than light waves
   C. have much shorter wavelengths than light waves
   D. are nearly monochromatic (single frequency)
   E. are amplitude modulated (AM).

   ans: B

3. Diffraction plays an important role in which of the following phenomena?
   A. The sun appears as a disk rather than a point to the naked eye
   B. Light is bent as it passes through a glass prism
   C. A cheerleader yells through a megaphone
   D. A farsighted person uses eyeglasses of positive focal length
   E. A thin soap film exhibits colors when illuminated with white light

   ans: C

4. The rainbow seen after a rain shower is caused by:
   A. diffraction
   B. interference
   C. refraction
   D. polarization
   E. absorption

   ans: C

5. When a highly coherent beam of light is directed against a very fine wire, the shadow formed behind it is not just that of a single wire but rather looks like the shadow of several parallel wires. The explanation of this involves:
   A. refraction
   B. diffraction
   C. reflection
   D. the Doppler effect
   E. an optical illusion

   ans: B

6. When the atmosphere is not quite clear, one may sometimes see colored circles concentric with the Sun or the Moon. These are generally not more than a few diameters of the Sun or Moon and invariably the innermost ring is blue. The explanation for this phenomena involves:
   A. reflection
   B. refraction
   C. interference
   D. diffraction
   E. the Doppler effect

   ans: D

7. The shimmering or wavy lines that can often be seen near the ground on a hot day are due to:
   A. Brownian movement
   B. reflection
   C. refraction
   D. diffraction
   E. dispersion

   ans: C

8. A point source of monochromatic light is placed in front of a soccer ball and a screen is placed behind the ball. The light intensity pattern on the screen is best described as:
   A. a dark disk on a bright background
   B. a dark disk with bright rings outside
   C. a dark disk with a bright spot at its center
   D. a dark disk with a bright spot at its center and bright rings outside
   E. a bright disk with bright rings outside

   ans: D

9. In the equation $\sin\theta = \lambda/a$ for single-slit diffraction, θ is:
   A. the angle to the first minimum
   B. the angle to the second maximum
   C. the phase angle between the extreme rays
   D. $N\pi$ where N is an integer
   E. $(N + 1/2)\pi$ where N is an integer

   ans: A

10. In the equation $\phi = (2\pi a/\lambda)\sin\theta$ for single-slit diffraction, ϕ is:
    A. the angle to the first minimum
    B. the angle to the second maximum
    C. the phase angle between the extreme rays
    D. $N\pi$ where N is an integer
    E. $(N + 1/2)\pi$ where N is an integer

    ans: C

11. No fringes are seen in a single-slit diffraction pattern if:

A. the screen is far away
B. the wavelength is less than the slit width
C. the wavelength is greater than the slit width
D. the wavelength is less than the distance to the screen
E. the distance to the screen is greater than the slit width

ans: C

12. A student wishes to produce a single-slit diffraction pattern in a ripple tank experiment. He considers the following parameters:

1. frequency
2. wavelength
3. water depth
4. slit width

Which two of the above should be decreased to produce more bending?

A. 1, 3
B. 1, 4
C. 2, 3
D. 2, 4
E. 3, 4

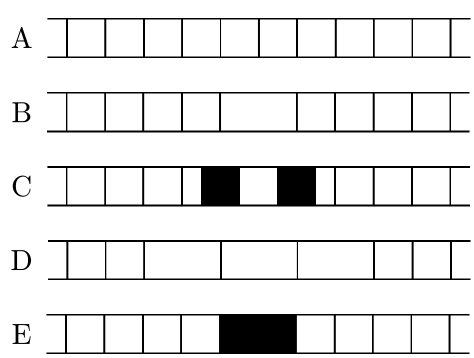
ans: B

13. A parallel beam of monochromatic light is incident on a slit of width 2 cm. The light passing through the slit falls on a screen 2 m away. As the slit width is decreased:

A. the width of the pattern on the screen continuously decreases
B. the width of the pattern on the screen at first decreases but then increases
C. the width of the pattern on the screen increases and then decreases
D. the width of the pattern on the screen remains the same
E. the pattern on the screen changes color going from red to blue

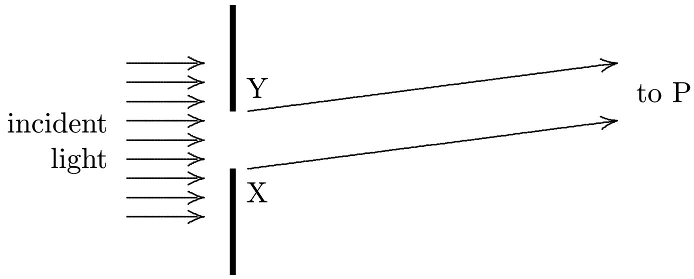
ans: B

14. Monochromatic plane waves of light are incident normally on a single slit. Which one of the five figures below correctly shows the diffraction pattern observed on a distant screen?



ans: B

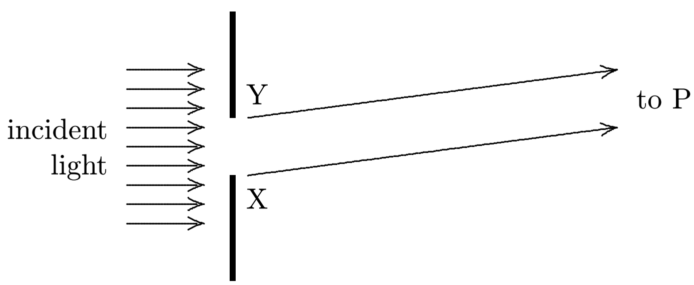
15. The diagram shows a single slit with the direction to a point P on a distant screen shown. At P, the pattern has its second minimum (from its central maximum). If X and Y are the edges of the slit, what is the path length difference (PX) - (PY)?



A. $\lambda/2$
B. λ
C. $3\lambda/2$
D. 2λ
E. $5\lambda/2$

ans: D

16. The diagram shows a single slit with the direction to a point P on a distant screen shown. At P, the pattern has its maximum nearest the central maximum. If X and Y are the edges of the slit, what is the path length difference (PX) - (PY)?



A. $\lambda/2$
B. λ
C. $3\lambda/2$
D. 2λ
E. $5\lambda/2$

ans: C

17. At the first minimum adjacent to the central maximum of a single-slit diffraction pattern the phase difference between the Huygens wavelet from the top of the slit and the wavelet from the midpoint of the slit is:

A. $\pi/8$ rad
B. $\pi/4$ rad
C. $\pi/2$ rad
D. π rad
E. $3\pi/2$ rad

ans: D

18. At the second minimum adjacent to the central maximum of a single-slit diffraction pattern the Huygens wavelet from the top of the slit is 180° out of phase with the wavelet from:
    A. a point one-fourth of the slit width from the top
    B. the midpoint of the slit
    C. a point one-fourth of the slit width from the bottom of the slit
    D. the bottom of the slit
    E. none of these

    ans: A

19. A plane wave with a wavelength of 500 nm is incident normally on a single slit with a width of 5.0×10^{-6} m. Consider waves that reach a point on a far-away screen such that rays from the slit make an angle of 1.0° with the normal. The difference in phase for waves from the top and bottom of the slit is:
    A. 0
    B. 0.55 rad
    C. 1.1 rad
    D. 1.6 rad
    E. 2.2 rad

    ans: C

20. A diffraction pattern is produced on a viewing screen by illuminating a long narrow slit with light of wavelength λ. If λ is increased and no other changes are made:
    A. the intensity at the center of the pattern decreases and the pattern expands away from the bright center
    B. the intensity at the center of the pattern increases and the pattern contracts toward the bright center
    C. the intensity at the center of the pattern does not change and the pattern expands away from the bright center
    D. the intensity at the center of the pattern does not change and the pattern contracts toward the bright center
    E. neither the intensity at the center of the pattern nor the pattern itself change

    ans: C

21. A diffraction pattern is produced on a viewing screen by illuminating a long narrow slit with light of wavelength λ. If the slit width is decreased and no other changes are made:
    A. the intensity at the center of the pattern decreases and the pattern expands away from the bright center
    B. the intensity at the center of the pattern increases and the pattern contracts toward the bright center
    C. the intensity at the center of the pattern does not change and the pattern expands away from the bright center
    D. the intensity at the center of the pattern does not change and the pattern contracts toward the bright center
    E. neither the intensity at the center of the pattern nor the pattern itself change

    ans: A

22. In order to obtain a good single-slit diffraction pattern, the slit width could be:
A. λ
B. $\lambda/10$
C. 10λ
D. $10^4\lambda$
E. $\lambda/10^4$
ans: C

23. Consider a single-slit diffraction pattern caused by a slit of width a. There is a maximum if $\sin\theta$ is equal to:
A. slightly more than $3\lambda/2a$
B. slightly less than $3\lambda/2a$
C. exactly $3\lambda/2a$
D. exactly $\lambda/2a$
E. very nearly $\lambda/2a$
ans: B

24. Consider a single-slit diffraction pattern caused by a slit of width a. There is a minimum if $\sin\theta$ is equal to:
A. exactly λ/a
B. slightly more than λ/a
C. slightly less than λ/a
D. exactly $\lambda/2a$
E. very nearly $\lambda/2a$
ans: A

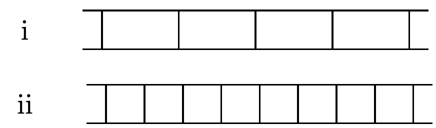
25. In a single-slit diffraction pattern, the central maximum is about twice as wide as the other maxima. This is because:
A. half the light is diffracted up and half is diffracted down
B. the central maximum has both electric and magnetic fields present
C. the small angle approximation applies only near the central maximum
D. the screen is flat instead of spherical
E. none of the above
ans: E

26. The intensity at a secondary maximum of a single-slit diffraction pattern is less than the intensity at the central maximum chiefly because:
A. some Huygens wavelets sum to zero at the secondary maximum but not at the central maximum
B. the secondary maximum is further from the slits than the central maximum and intensity decreases as the square of the distance
C. the Huygens construction is not valid for a secondary maximum
D. the amplitude of every Huygens wavelet is smaller when it travels to a secondary maximum than when it travels to the central maximum
E. none of the above
ans: A

27. Figure (i) shows a double-slit pattern obtained using monochromatic light. Consider the following five possible changes in conditions:

1. decrease the frequency
2. increase the frequency
3. increase the width of each slit
4. increase the separation between the slits
5. decrease the separation between the slits

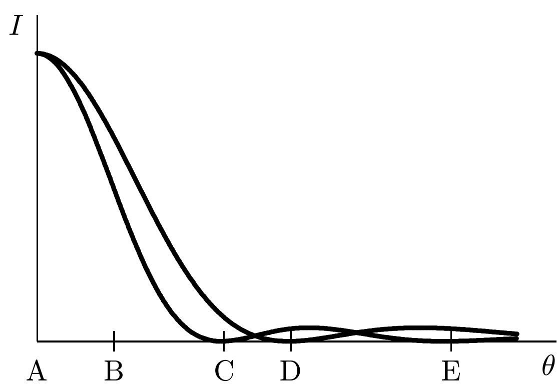
Which of the above would change Figure (i) into Figure (ii)?



A. 3 only
B. 5 only
C. 1 and 3 only
D. 1 and 5 only
E. 2 and 4 only

ans: E

28. Two wavelengths, 800 nm and 600 nm, are used separately in single-slit diffraction experiments. The diagram shows the intensities on a far-away viewing screen as function of the angle made by the rays with the straight-ahead direction. If both wavelengths are then used simultaneously, at which angle is the light on the screen purely 800-nm light?



ans: C

29. If we increase the wavelength of the light used to form a double-slit diffraction pattern:

A. the width of the central diffraction peak increases and the number of bright fringes within the peak increases
B. the width of the central diffraction peak increases and the number of bright fringes within the peak decreases
C. the width of the central diffraction peak decreases and the number of bright fringes within the peak increases
D. the width of the central diffraction peak decreases and the number of bright fringes within the peak decreases
E. the width of the central diffraction peak increases and the number of bright fringes within the peak stays the same

ans: E

30. Two slits of width a and separation d are illuminated by a beam of light of wavelength λ. The separation of the interference fringes on a screen a distance D away is:

A. $\lambda a/D$
B. $\lambda d/D$
C. $\lambda D/d$
D. dD/λ
E. $\lambda D/a$

ans: C

31. Two slits in an opaque barrier each have a width of 0.020 mm and are separated by 0.050 mm. When coherent monochromatic light passes through the slits the number of interference maxima within the central diffraction maximum:

A. is 1
B. is 2
C. is 4
D. is 5
E. cannot be determined unless the wavelength is given

ans: D

32. When 450-nm light is incident normally on a certain double-slit system the number of interference maxima within the central diffraction maximum is 5. When 900-nm light is incident on the same slit system the number is:

A. 2
B. 3
C. 5
D. 9
E. 10

ans: C

33. In a double-slit diffraction experiment the number of interference fringes within the central diffraction maximum can be increased by:

A. increasing the wavelength
B. decreasing the wavelength
C. decreasing the slit separation
D. increasing the slit width
E. decreasing the slit width

ans: E

34. A diffraction-limited laser of length ℓ and aperture diameter d generates light of wavelength λ. If the beam is directed at the surface of the Moon a distance D away, the radius of the illuminated area on the Moon is approximately:

A. dD/ℓ
B. dD/λ
C. $D\lambda/\ell$
D. $D\lambda/d$
E. $\ell\lambda/d$

ans: D

35. Two stars that are close together are photographed through a telescope. The black and white film is equally sensitive to all colors. Which situation would result in the most clearly separated images of the stars?

A. Small lens, red stars
B. Small lens, blue stars
C. Large lens, red stars
D. Large lens, blue stars
E. Large lens, one star red and the other blue

ans: D

36. The resolving power of a telescope can be increased by:

A. increasing the objective focal length and decreasing the eyepiece focal length
B. increasing the lens diameters
C. decreasing the lens diameters
D. inserting a correction lens between objective and eyepiece
E. none of the above

ans: B

37. In the equation $d \sin\theta = m\lambda$ for the lines of a diffraction grating m is:

A. the number of slits
B. the slit width
C. the slit separation
D. the order of the line
E. the index of refraction

ans: D

38. In the equation $d \sin\theta = m\lambda$ for the lines of a diffraction grating d is:

A. the number of slits
B. the slit width
C. the slit separation
D. the order of the line
E. the index of refraction

ans: C

39. As more slits with the same spacing are added to a diffraction grating the lines:

A. spread farther apart
B. move closer together
C. become wider
D. becomes narrower
E. do not change in position or width

ans: D

40. An N-slit system has slit separation d and slit width a. Plane waves with intensity I and wavelength λ are incident normally on it. The angular separation of the lines depends only on:

A. a and N
B. a and λ
C. N and λ
D. d and λ
E. I and N

ans: D

41. 600-nm light is incident on a diffraction grating with a ruling separation of 1.7×10^{-6} m. The second order line occurs at a diffraction angle of:

A. 0
B. 10°
C. 21°
D. 42°
E. 45°

ans: E

42. The widths of the lines produced by monochromatic light falling on a diffraction grating can be reduced by:

A. increasing the wavelength of the light
B. increasing the number of rulings without changing their spacing
C. decreasing the spacing between adjacent rulings without changing the number of rulings
D. decreasing both the wavelength and the spacing between rulings by the same factor
E. increasing the number of rulings and decreasing their spacing so the length of the grating remains the same

ans: B

43. Monochromatic light is normally incident on a diffraction grating that is 1 cm wide and has 10,000 slits. The first order line is deviated at a 30° angle. What is the wavelength, in nm, of the incident light?

A. 300
B. 400
C. 500
D. 600
E. 1000

ans: C

44. A light spectrum is formed on a screen using a diffraction grating. The entire apparatus (source, grating and screen) is now immersed in a liquid of refractive index 1.33. As a result, the pattern on the screen:

A. remains the same
B. spreads out
C. crowds together
D. becomes reversed, with the previously blue end becoming red
E. disappears because the refractive index isn't an integer

ans: C

45. The spacing between adjacent slits on a diffraction grating is 3λ. The deviation θ of the first order diffracted beam is given by:

A. $\sin(\theta/2) = 1/3$
B. $\sin(\theta/3) = 2/3$
C. $\sin(\theta) = 1/3$
D. $\tan(\theta/2) = 1/3$
E. $\tan(\theta) = 2/3$

ans: C

46. When light of a certain wavelength is incident normally on a certain diffraction grating the line of order 1 is at a diffraction angle of 25°. The diffraction angle for the second order line is:

A. 25°
B. 42°
C. 50°
D. 58°
E. 75°

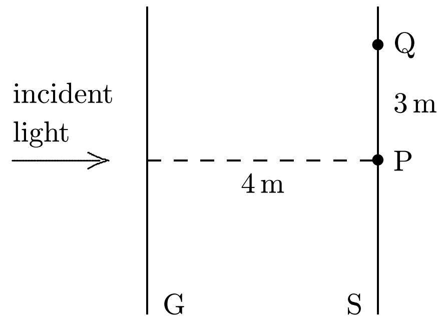
ans D

47. A diffraction grating of width W produces a deviation θ in second order for light of wavelength λ. The total number N of slits in the grating is given by:

A. $2W\lambda/\sin\theta$
B. $(W/\lambda)\sin\theta$
C. $\lambda W/2\sin\theta$
D. $(W/2\lambda)\sin\theta$
E. $2\lambda/\sin\theta$

ans: D

48. Light of wavelength λ is normally incident on a diffraction grating G. On the screen S, the central line is at P and the first order line is at Q, as shown. The distance between adjacent slits in the grating is:



A. $3\lambda/5$
B. $3\lambda/4$
C. $4\lambda/5$
D. $5\lambda/4$
E. $5\lambda/3$
ans: E

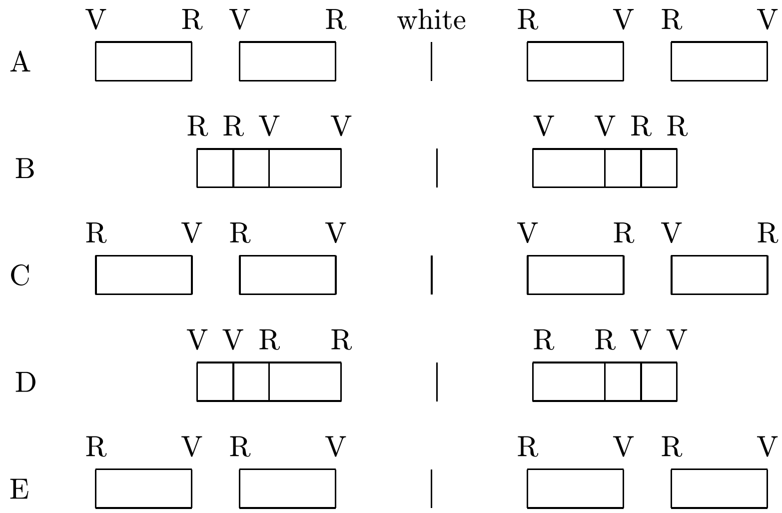
49. 550-nm light is incident normally on a diffraction grating and exactly 6 lines are produced. The ruling separation must be:

A. between 2.75×10^{-7} m and 5.50×10^{-7} m
B. between 5.50×10^{-7} m and 1.10×10^{-6} m
C. between 3.30×10^{-6} m and 3.85×10^{-6} m
D. between 3.85×10^{-6} m and 4.40×10^{-6} m
E. greater than 4.40×10^{-6} m
ans: E

50. A mixture of 450-nm and 900-nm light is incident on a diffraction grating. Which of the following is true?

A. all lines of the 900-nm light coincide with even order lines of the 450-nm light
B. all lines of the 450-nm light coincide with even order lines of the 900-nm light
C. all lines of the 900-nm light coincide with odd order lines of the 450-nm light
D. None of the lines of the 450-nm light coincide with lines of the 900-nm light
E. All of the lines of the 450-nm light coincide with lines of the 900-nm light
ans: A

51. A beam of white light (from 400 nm for violet to 700 nm for red) is normally incident on a diffraction grating. It produces two orders on a distant screen. Which diagram below (R = red, V = violet) correctly shows the pattern on the screen?



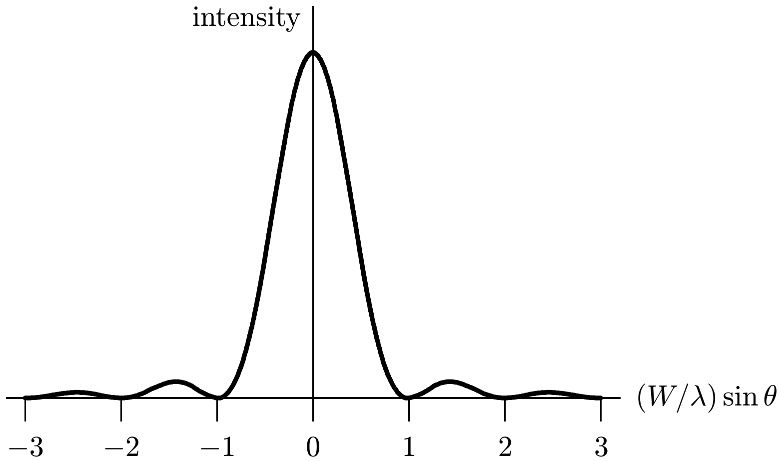
ans: C

52. If white light is incident on a diffraction grating:

A. the first order lines for all visible wavelengths occur at smaller diffraction angles than any of the second order lines
B. some first order lines overlap the second order lines if the ruling separation is small but do not if it is large
C. some first order lines overlap second order lines if the ruling separation is large but do not if it is small
D. some first order lines overlap second order lines no matter what the ruling separation
E. first and second order lines have the same range of diffraction angles

ans: A

53. Light of wavelength is normally incident on some plane optical device. The intensity pattern shown is observed on a distant screen (θ is the angle measured from the normal of the device). The device could be:



A. a single slit of width W
B. a single slit of width $2W$
C. two narrow slits with separation W
D. two narrow slits with separation $2W$
E. a diffraction grating with slit separation W

ans: A

54. A person with her eye relaxed looks through a diffraction grating at a distant monochromatic point source of light. The slits of the grating are vertical. She sees:

A. one point of light
B. a hazy horizontal strip of light of the same color as the source
C. a hazy strip of light varying from violet to red
D. a sequence of horizontal points of light
E. a sequence of closely spaced vertical lines

ans: D

55. Monochromatic light is normally incident on a diffraction grating. The m^{th} order line is at a diffraction angle θ and has width w. A wide single slit is now placed in front of the grating and its width is then slowly reduced. As a result:

A. both θ and w increase
B. both θ and w decrease
C. θ remains the same and w increases
D. θ remains the same and w decreases
E. θ decreases and w increases

ans: C

56. At a diffraction line phasors associated with waves from the slits of a multiple-slit barrier:
   A. are aligned
   B. form a closed polygon
   C. form a polygon with several sides missing
   D. are parallel but adjacent phasors point in opposite directions
   E. form the arc of a circle

   ans: A

57. For a certain multiple-slit barrier the slit separation is 4 times the slit width. For this system:
   A. the orders of the lines that appear are all multiples of 4
   B. the orders of lines that appear are all multiples of 2
   C. the orders of the missing lines are all multiples of 4
   D. the orders of the missing lines are all multiples of 2
   E. none of the above are true

   ans: C

58. The dispersion D of a grating can have units:
   A. cm
   B. 1/nm
   C. nm/cm
   D. radian
   E. none of these

   ans: B

59. The resolving power R of a grating can have units:
   A. cm
   B. degree/nm
   C. watt
   D. nm/cm
   E. watt/nm

   ans: D

60. The dispersion of a diffraction grating indicates:
   A. the resolution of the grating
   B. the separation of lines of the same order
   C. the number of rulings in the grating
   D. the width of the lines
   E. the separation of lines of different order for the same wavelength

   ans: B

61. The resolving power of a diffraction grating is defined by $R = \lambda/\Delta\lambda$. Here λ and $\lambda + \Delta\lambda$ are:

A. any two wavelengths
B. any two wavelengths that are nearly the same
C. two wavelengths for which lines of the same order are separated by π radians
D. two wavelengths for which lines of the same order are separated by 2π radians
E. two wavelengths for which lines of the same order are separated by half the width of a maximum

ans: E

62. A light beam incident on a diffraction grating consists of waves with two different wavelengths. The separation of the two first order lines is great if:

A. the dispersion is great
B. the resolution is great
C. the dispersion is small
D. the resolution is small
E. none of the above (line separation does not depend on either dispersion or resolution)

ans: A

63. To obtain greater dispersion by a diffraction grating:

A. the slit width should be increased
B. the slit width should be decreased
C. the slit separation should be increased
D. the slit separation should be decreased
E. more slits with the same width and separation should be added to the system

ans: D

64. Two nearly equal wavelengths of light are incident on an N-slit grating. The two wavelengths are not resolvable. When N is increased they become resolvable. This is because:

A. more light gets through the grating
B. the lines get more intense
C. the entire pattern spreads out
D. there are more orders present
E. the lines become more narrow

ans: E

65. A diffraction grating just resolves the wavelengths 400.0 nm and 400.1 nm in first order. The number of slits in the grating is:

A. 400
B. 1000
C. 2500
D. 4000
E. not enough information is given

ans: D

66. What is the minimum number of slits required in a diffraction grating to just resolve light with wavelengths of 471.0 nm and 471.6 nm?

A. 99
B. 197
C. 393
D. 786
E. 1179

ans: C

67. X rays are:

A. electromagnetic waves
B. negatively charged ions
C. rapidly moving electrons
D. rapidly moving protons
E. rapidly moving neutrons

ans: A

68. Bragg's law for x-ray diffraction is $2d \sin\theta = m\lambda$, where θ is the angle between the incident beam and:

A. a reflecting plane of atoms
B. the normal to a reflecting plane of atoms
C. the scattered beam
D. the normal to the scattered beam
E. the refracted beam

ans: A

69. Bragg's law for x-ray diffraction is $2d \sin\theta = m\lambda$, where the quantity d is:

A. the height of a unit cell
B. the smallest interatomic distance
C. the distance from detector to sample
D. the distance between planes of atoms
E. the usual calculus symbol for a differential

ans: D

70. Which of the following is true for Bragg diffraction but not for diffraction from a grating?

A. Two different wavelengths may be used
B. For a given wavelength, a maximum may exist in several directions
C. Long waves are deviated more than short ones
D. There is only one grating spacing
E. Maxima occur only for particular angles of incidence

ans: E

71. The longest x-ray wavelength that can be diffracted by crystal planes with a separation of 0.316 nm is:

A. 0.158 nm
B. 0.316 nm
C. 0.474 nm
D. 0.632 nm
E. 1.26 nm

ans: D

72. A beam of x rays of wavelength 0.20 nm is diffracted by a set of planes in a crystal whose separation is 3.1×10^{-8} cm. The smallest angle between the beam and the crystal planes for which a reflection occurs is:

A. 0.70 rad
B. 0.33 rad
C. 0.033 rad
D. 0.066 rad
E. no such angle exists

ans: C

73. An x-ray beam of wavelength 3×10^{-11} m is incident on a calcite crystal of lattice spacing 0.3 nm. The smallest angle between crystal planes and the x-ray beam that will result in constructive interference is:

A. 2.87°
B. 5.73°
C. 11.63°
D. 23.27°
E. none of these

ans: A

74. A beam of x rays of wavelength 0.10 nm is found to diffract in second order from the face of a LiF crystal at a Bragg angle of 30°. The distance between adjacent crystal planes, in nm, is about:

A. 0.15
B. 0.20
C. 0.25
D. 0.30
E. 0.40

ans: B