

Respostas

Respostas dos exercícios e problemas de numeração ímpar

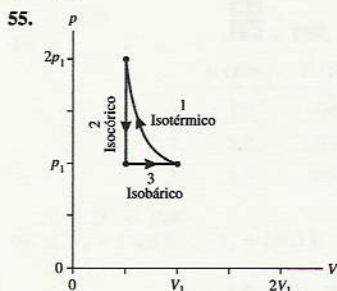
Capítulo 15

1. 960 kg/m^3
3. $1,44 \times 10^5 \text{ kg}$
5. $1,10 \times 10^3 \text{ atmosferas}$
7. $2,4 \times 10^3 \text{ kg}$
9. $3,2 \text{ km}$
11. $10,3 \text{ m}$
13. $10,3 \text{ m}$
15. $7,9 \times 10^2 \text{ kg/m}^3$; álcool etílico
17. 750 kg/m^3
19. $1,87 \text{ N}$
21. $1,11 \text{ kN}$
23. $3,2 \text{ m/s}$
27. $1,02 \text{ cm}$
29. $2,0 \text{ kg}$
31. a. $5,057 \times 10^7 \text{ Pa}$ b. $-0,025$ c. 1056 kg/m^3
33. a. $2,9 \times 10^4 \text{ N}$ b. 30 jogadores
35. 27 psi
37. $5,27 \times 10^{18} \text{ kg}$
39. a. $10,85 \text{ m}$ b. $10,21 \text{ m}$
41. a. $0,48 \text{ m}$ b. $2,3 \text{ cm}$
45. $7,5 \text{ cm}$
47. a. $\frac{1}{2} \rho g w d^2$ b. $1,76 \times 10^9 \text{ N}$
49. a. 8080 m b. $1,05 \text{ kg/m}^3$, 82%
51. a. $\rho_{\text{liq}} A g x$ b. $0,62 \text{ J}$
53. $8,9 \times 10^2 \text{ kg/m}^3$
55. $18,1 \text{ cm}$
57. $5,2 \text{ cm}$
59. 53 kPa
61. a. p_{atm} b. $4,6 \text{ m}$
63. a. Menor b. $0,83 \text{ kPa}$ c. $7,5 \times 10^4 \text{ N}$, para fora
65. a. $v_1 = 144 \text{ m/s}$, $v_2 = 5,8 \text{ m/s}$ b. $4,5 \times 10^{-3} \text{ m}^3/\text{s}$
67. a. $3,3 \text{ L/min}$ b. $1,06 \text{ mm/min}$
69. $6,9 \text{ km}$
71. 76 cm
73. 53 kPa
75. $\frac{R^2}{r^2} \sqrt{\frac{2d}{g}}$

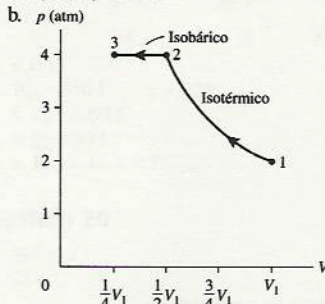
Capítulo 16

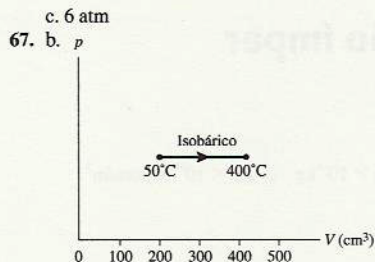
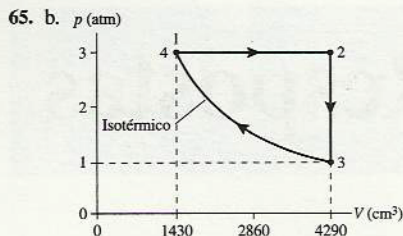
1. $22,6 \text{ m}^3$
3. $4,2 \text{ cm}$
5. $4,8 \times 10^{23} \text{ átomos}$
7. a. $6,02 \times 10^{28} \text{ átomos/m}^3$ b. $3,28 \times 10^{28} \text{ átomos/m}^3$
9. $4,06 \text{ cm}$
11. $-127^\circ\text{F} = -88^\circ\text{C} = 185 \text{ K}$, $136^\circ\text{F} = 58^\circ\text{C} = 331 \text{ K}$
13. a. 171°Z b. 944°Z
15. 19 atm

17. a. $0,050 \text{ m}^3$ b. $1,3 \text{ atm}$
19. a. 55 mol b. $1,2 \text{ m}^3$
21. a. $5,4 \times 10^{23} \text{ átomos}$ b. $3,6 \times 10^{-3} \text{ kg}$ c. $2,3 \times 10^{26} \text{ átomos/m}^3$
d. $1,5 \text{ kg/m}^3$
23. a. $V_2 = V_1$ b. $T_2 = T_1/3$
25. a. $0,73 \text{ atm}$ b. $0,52 \text{ atm}$
27. a. 9500 kPa
29. a. 48 atm
31. a. Isotérmico b. 641°C c. 300 cm^3
33. $0,228 \text{ nm}$
35. $3,3 \times 10^{26} \text{ prótons}$
37. $1,1 \times 10^{15} \text{ partículas/m}^3$
39. a. $1,3 \times 10^{-13}$ b. $1,2 \times 10^{11} \text{ moléculas}$
41. $1,8 \text{ g}$
43. 174°C
45. 93 cm^3
47. 35 psi
49. $174,3^\circ\text{C}$
51. $24,0 \text{ cm}$
53. Não



57. a. 880 kPa b. $T_2 = 323^\circ\text{C}$, $T_3 = -49^\circ\text{C}$, $T_4 = 398^\circ\text{C}$
59. a. $T_1 = 366 \text{ K}$, $T_2 = 366 \text{ K}$ b. Isotérmico c. 825°C
61. 2364°C
63. a. $4,0 \text{ atm}$, -73°C

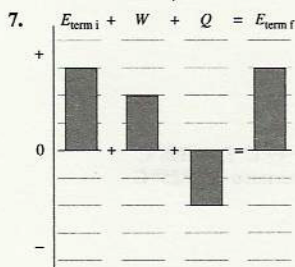
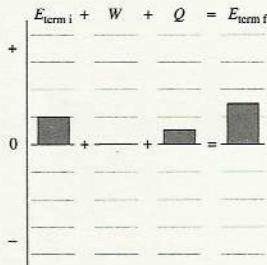




- c. 417 cm³
69. a. 23,5 cm b. 7,8 cm
71. 2,4 m
73. a. $4,0 \times 10^5$ Pa b. Irreversível

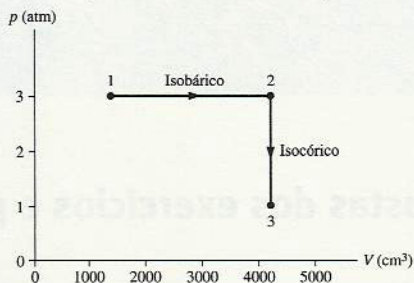
Capítulo 17

1. 40 J
3. 200 cm³
5.

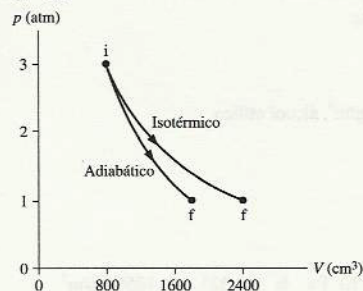


9. 700 J cedidos pelo sistema
11. 12.000 J
13. 6860 J
15. $6,8 \times 10^4$ J
17. 28°C
19. 73,5°C
21. Ferro
23. a. 91 J b. 140°C
25. a. 1,32 b. 1,25
27. a. 1,1 atm b. 48°C
29. Ferro
31. 26 W
33. 8,7 h
35. 990 cm³
37. -56°C
39. Alumínio
41. 87 min
43. $-3,4 \times 10^5$ J
45. 5500 J
47. 2,8 atm
49. 1660 J

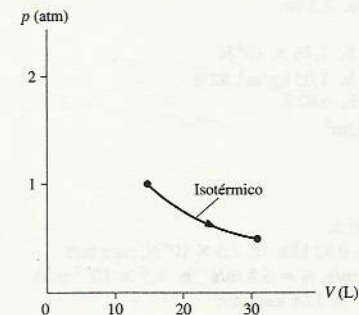
51. a. 253°C b. 33 cm
53. a. 110 kPa b. 24 cm
55. a. $V_2 = 4300 \text{ cm}^3$ $T_2 = 606^\circ\text{C}$ b. 3000 J c. 1,0 atm d. 2200 J
e.



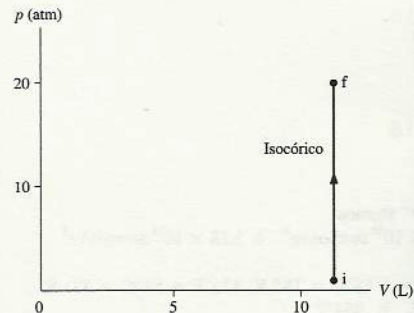
57. Para a: -1.000 J; para B: 1.400 J
59. a. -410 J b. 570 J c. 0 J
61. a. $T_{Af} = 300 \text{ K}$, $T_{Bf} = 220 \text{ K}$, $V_{Af} = 2,5 \times 10^{-3} \text{ m}^3$,
 $V_{Bf} = 1,8 \times 10^{-3} \text{ m}^3$
b.



63. a. -50,7 J b. -15 J c. 36 J
65. $T_f = 830^\circ\text{C}$, $V_f = 24 \text{ cm}^3$
67. a. 39,3 b. 171
69. a. 0,50 atm b. -1070 J c. 1070 J d. 0 J
e.



71. a. 5500 K b. 0 J c. $5,4 \times 10^4$ J d. 20
e.



73. 110°C
75. -118°C
77. b. 217°C
79. a.

Ponto	p (atm)	T (°C)	V (cm ³)
1	3,0	946	1000
2	1,0	946	3000
3	0,48	310	3000

- b. $W_{1 \rightarrow 2} = -334 \text{ J}$, $W_{2 \rightarrow 3} = 0 \text{ J}$, $W_{3 \rightarrow 1} = 239 \text{ J}$
 c. $Q_{1 \rightarrow 2} = 334 \text{ J}$, $Q_{2 \rightarrow 3} = -239 \text{ J}$, $Q_{3 \rightarrow 1} = 0 \text{ J}$

81. 15 atm
 83. a. 606°C b. 150 J

Capítulo 18

1. $2,69 \times 10^{25} \text{ m}^{-3}$
 3. 0,023 Pa
 5. a. 300 nm b. 600 nm
 7. 12,5 cm
 9. a. $(0\hat{i} + 0\hat{j}) \text{ m/s}$ b. 59 m/s c. 62 m/s
 11. a. 9,16 Pa b. 332 K
 13. Neônio
 15. 2,5 mK
 17. -246°C
 19. 800 m/s
 21. $7,22 \times 10^{12} \text{ K}$
 23. a. 3400 J b. 3400 J c. 3400 J
 25. a. $4,1 \times 10^{-16} \text{ J}$ b. $7,0 \times 10^5 \text{ m/s}$
 27. 490 J
 29. $3,6 \times 10^7 \text{ J}$
 31. a. $0,080^\circ\text{C}$ b. $0,048^\circ\text{C}$ c. $0,040^\circ\text{C}$
 33. a. 62 J b. 100 J c. 100 J d. 150 J
 35. a. B b. $E_{\text{Al}} = 5.200 \text{ J}$, $E_{\text{Bi}} = 7.800 \text{ J}$
 37. 84,8
 39. a. Hélio b. 1370 m/s c. $1,86 \mu\text{m}$
 41. $9,6 \times 10^{-5} \text{ m/s}$
 43. a. $\lambda_{\text{elétron}} = \frac{1}{\sqrt{2\pi(N/V)r^2}}$
 b. $1,82 \times 10^{-6} \text{ Pa} = 1,80 \times 10^{-11} \text{ atm}$
 45. a. $1,3 \times 10^{25} \text{ m}^{-3}$ b. 450 m/s c. 260 m/s d. $1,3 \times 10^{22} \text{ s}^{-1}$
 e. 57 kPa f. 57 kPa
 47. 29 J/mol K
 49. a. $(E_{\text{He}})_i = 1900 \text{ J}$, $(E_{\text{O}})_i = 3100 \text{ J}$ b. $(E_{\text{He}})_f = 2700 \text{ J}$, $(E_{\text{O}})_f = 2300 \text{ J}$ c. 850 J cedidos pelo oxigênio ao hélio d. 436 K
 51. 7
 55. a. R b. 2R
 57. a. 4 b. 1 c. 16
 59. a. 141.000 T b. 10.100 K c. Para o N_2 , $\epsilon_{\text{med}}/K_{\text{escape}} = 0,2\%$; para o H_2 , $\epsilon_{\text{med}}/K_{\text{escape}} = 3\%$
 61. a. $2,0 \times 10^6 \text{ J}$ b. $4,8 \times 10^{-6}$ c. $0,0013^\circ\text{C}$
 63. b. $9p_1V_1$
 65. c. 436 K; 850 J são transferidos do oxigênio para o hélio

Capítulo 19

1. a. 250 J b. 150 J
 3. a. 0,27 b. 14 kJ
 5. a. 200 J b. 250 J
 7. 96.000
 9.
- | | ΔE_{term} | W_s | Q |
|---|--------------------------|-------|-----|
| A | + | 0 | + |
| B | 0 | + | + |
| C | - | + | 0 |
| D | - | - | - |
11. 20,5 J
 13. a. $W_{\text{saída}} = 10 \text{ J}$, $Q_c = 110 \text{ J}$ b. 0,083
 15. 283 J
 17. 25
 19. a. (b) b. (a)
 21. 7°C
 23. a. 0,40 b. 215°C
 25. 135°C
 27. a. 6,33 b. 32 W c. 232 W
 29. a. 60 J b. -23°C
 31. $1,7 \times 10^6 \text{ J}$
 34. 1200 W
 37. a. $3,63 \times 10^6 \text{ J}$ b. $3,0 \times 10^5 \text{ J}$
 39. 560 J

41. 1820°C
 43. a. $Q_1 = 1000 \text{ J}$ $Q_2 = 500 \text{ J}$ $Q_3 = 2500 \text{ J}$ $Q_4 = 2000 \text{ J}$
 b. $Q_3 > Q_1$ c. Não
 45. Não
 47. a. 48 m b. 0,32
 49. 0,37
 51. a. 5,0 kW b. 1,7
 53. a.

	$W_s \text{ (J)}$	$Q \text{ (J)}$	ΔE_{term}
1 $\rightarrow$ 2	3,04	16,97	13,93
2 $\rightarrow$ 3	0	-10,13	-10,13
3 $\rightarrow$ 1	-1,52	-5,32	-3,80
Tot	1,52	1,52	0

- b. 0,090 c. 13 W

55. a.

	$W_s \text{ (J)}$	$Q \text{ (J)}$	$\Delta E_{\text{term}} \text{ (J)}$
1 $\rightarrow$ 2	0	282,2	282,2
2 $\rightarrow$ 3	207,2	0	-207,2
3 $\rightarrow$ 1	-50,0	-125,0	-75,0
Tot	157,2	157,2	0

- b. 0,52

57. a. $V_1 = 4000 \text{ cm}^3$ $p_1 = 5,7 \text{ kPa}$ $T_1 = 230 \text{ K}$
 b.

	$\Delta E_{\text{term}} \text{ (J)}$	$W_s \text{ (J)}$	$Q \text{ (J)}$
1 $\rightarrow$ 2	425,7	-425,7	0
2 $\rightarrow$ 3	0	554,5	554,5
3 $\rightarrow$ 1	-425,7	0	-425,7
Tot	0	128,8	128,8

- c. 0,23

59. a.

	$p \text{ (atm)}$	$T \text{ (K)}$	$V \text{ (cm}^3\text{)}$
1	1,0	406	1000
2	5,0	2030	1000
3	1,0	2030	5000

- b. 0,29 c. 0,80

61. a. $T_1 = 1620 \text{ K}$ $T_2 = 2407 \text{ K}$ $T_3 = 6479 \text{ K}$
 b.

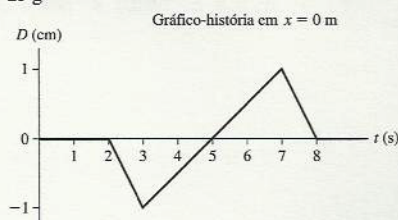
	$\Delta E_{\text{term}} \text{ (J)}$	$W_s \text{ (J)}$	$Q \text{ (J)}$
1 $\rightarrow$ 2	327	-327	0
2 $\rightarrow$ 3	1692	677	2369
3 $\rightarrow$ 1	-2019	0	-2019
Tot	0	350	350

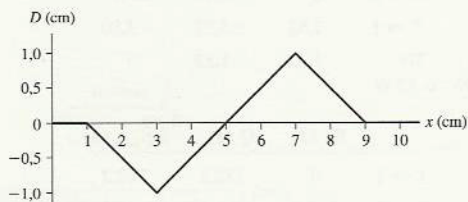
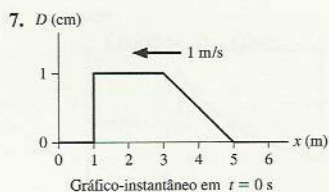
- c. 0,15

63. $W_{\text{tot}} = 350 \text{ J}$ $\eta = 0,24$
 65. b. $T_H = 1092^\circ\text{C}$
 67. b. $Q_c = 80 \text{ J}$
 69. b. 10,13' J c. 0,13

Capítulo 20

1. 283 m/s
 3. 25 g
 5.

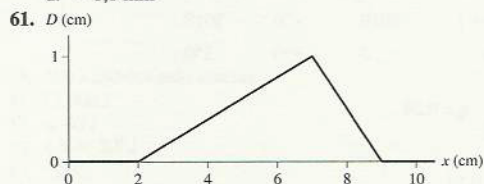




11. a. 4,2 m b. 48 Hz
13. a. 11 Hz b. 1,1 m c. 13 m/s
15. 40 cm
17. 34 Hz, 68 Hz
19. 6100 m/s
21. a. 1700 Hz b. 1,5 GHz c. 990 nm
23. a. 10 GHz b. 0,17 ms
25. a. $1,5 \times 10^{-11}$ s b. 3,4 mm
27. a. $8,6 \times 10^8$ Hz b. 23 cm
29. $6,0 \times 10^5$ J
31. a. 1,1 mW/m² b. $1,1 \times 10^{-7}$ J
33. a. 47 dB b. 107 dB
35. 20 m
37. a. 432 Hz b. 429 Hz
39. 38,1 m/s
41. a. 0,80 m b. $-\pi/2$ rad

c. $D(x, t) = (2,0 \text{ mm}) \sin \left[\frac{2\pi x}{0,80 \text{ m}} - \frac{2\pi t}{0,20 \text{ s}} - \frac{\pi}{2} \right]$

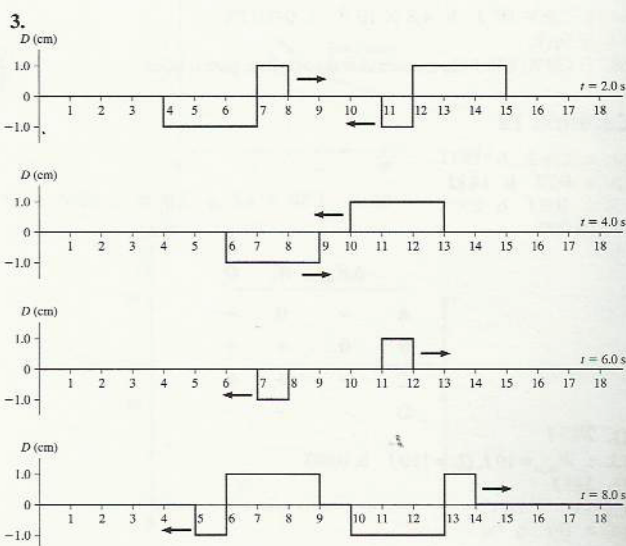
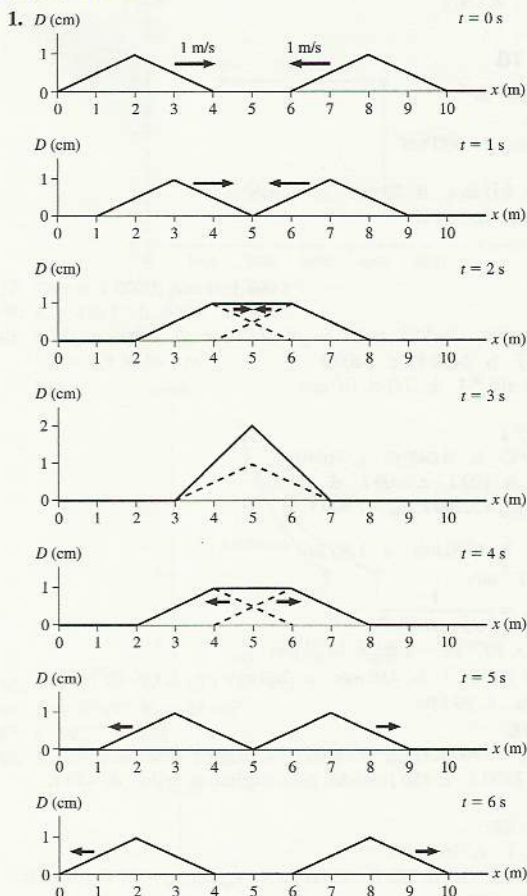
43. 1100 m/s
45. $L_1 = 2,3$ m, $L_2 = 1,7$ m
47. 790 m
49. 459 nm
51. 1230 km
53. a. Sentido negativo de x b. $v = 12$ m/s $f = 5,0$ Hz $k = 2,6$ rad/m
c. -1,5 cm
55. $D(y, t) = (5,0 \text{ cm}) \sin [(4\pi \text{ rad/m})y + (16\pi \text{ rad/s})t]$
59. a. $v = 100$ m/s, $\lambda = 1,0$ m b. $A = 1,0$ mm, $\phi_0 = -\pi/2$ rad
c. $D(x, t) = (1,0 \text{ mm}) \sin [(2\pi \text{ rad/m})x - (200\pi \text{ rad/s})t - \pi/2 \text{ rad}]$
d. -1,0 mm

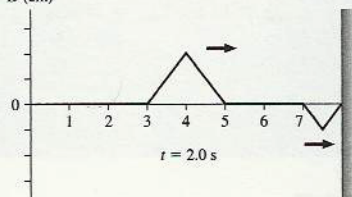
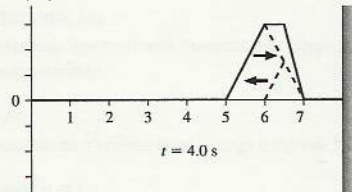
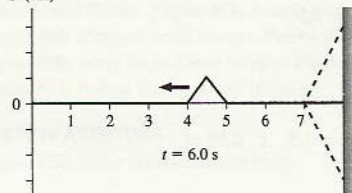
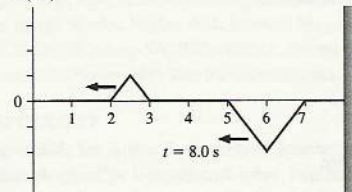


63. $f = 16$ Hz, $A = 2,0$ cm
65. $2,0 \times 10^{-5}$ W/m²
67. a. $250 \mu\text{W/m}^2$ b. 16 km
69. 78 dB
71. 86 m/s, afastando-se
75. 800 nm, infravermelha
77. R\$ 200.000.000,00

79. 0,07°C

Capítulo 21



5. D (cm) D (cm) D (cm) D (cm)

7. 30 m/s

9. a. 12 Hz, 24 m/s

11. a. 0,81 m b. 70 m

13. $2,830 \times 10^{13}$ Hz

15. 400 m/s

17. 10,5 m

19. 4,8 cm

21. a. 25 cm b. 25 cm

23. 216 nm

25. a. Em fase

27. Completamente destrutiva

b.

	r_1	r_2	Δr	C/D
P	3λ	4λ	λ	C
Q	$\frac{7}{2}\lambda$	2λ	$\frac{3}{2}\lambda$	D
R	$\frac{5}{2}\lambda$	$\frac{7}{2}\lambda$	λ	C

29. 203 Hz

31. 780,54530 nm

33. $A(x = 10 \text{ cm}) = 0,62 \text{ cm}$, $A(x = 20 \text{ cm}) = 1,18 \text{ cm}$, $A(x = 30 \text{ cm}) = 1,62 \text{ cm}$, $A(x = 40 \text{ cm}) = 1,90 \text{ cm}$, $A(x = 50 \text{ cm}) = 2,00 \text{ cm}$

35. 1,4 cm

37. 28,4 cm

39. a. 700 Hz b. 56 N

41. $8,2 \text{ m/s}^2$

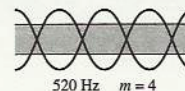
43. a. 240 Hz b. 3

45. 11 Hz

47. a. 10,5 GHz, 12,0 GHz, 13,5 GHz, 15,0 GHz, 16,5 GHz, 18,0 GHz, 19,5 GHz, b. 10,5 GHz, 13,5 GHz, 16,5 GHz, 19,5 GHz

49. a. Aberto-aberto

c.



d. 318 Hz, 424 Hz, 530 Hz

51. 1210 Hz

53. 18 cm

55. 273 m/s

57. 93 m

59. 7,9 cm

61. a. 850 Hz b. $-\frac{\pi}{2}$ rad

63. a. 473 nm b. 406 nm, 568 nm c. Amarelo-esverdeado

65. 7,15 cm

67. 20

69. a. 170 Hz b. 170 Hz, 510 Hz, 850 Hz

71. 150 MHz

73. a. a b. 1,0 m c. 9

75. a. 5 b. 4,6 mm

77. 7,0 m/s

79. 4,0 cm, 35 cm, 65 cm

81. 18 cm

83. a. $\lambda_1 = 20,0 \text{ m}$, $\lambda_2 = 10,0 \text{ m}$, $\lambda_3 = 6,67 \text{ m}$ b. $v_1 = 5,59 \text{ m/s}$, $v_2 = 3,95 \text{ m/s}$, $v_3 = 3,22 \text{ m/s}$ d. $T_1 = 3,58 \text{ s}$, $T_2 = 2,53 \text{ s}$, $T_3 = 2,07 \text{ s}$ **Capítulo 22**1. $0,020 \text{ rad} = 1,15^\circ$

3. 450 nm

5. 0,36 mm

7. 500 nm

9. $3,2^\circ$, $6,3^\circ$

11. 53014,5 cm

13. 14,5 cm

15. 0,20 mm

17. 610 nm

18. 4,0 mm

21. 7,6 m

23. $0,015 \text{ rad} = 0,87^\circ$

25. 78 cm

27. 30.467

29. 0,2895 mm

31. a. Fenda simples b. 0,15 mm

33. 1,3 mm

35. 500 nm

37. 500 nm

39. 667,8 nm

41. a. 1,3 m b. 7

43. 43 cm

45. 500 nm

47. 0,12 mm

49. 609 nm

51. 895 nm

53. 670 nm

55. 1,2 mm

57. a. 550 nm b. 0,40 mm

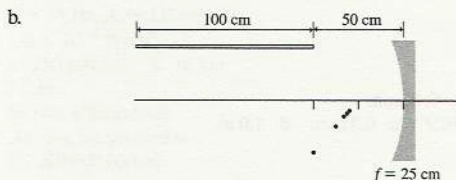
59. a. Não b. $0,029^\circ$ c. 0,31 cm d. 1,0 m

61. a. 3,0 mm b. 1/4 c. $\pi/2$ rad d. 0,75 mm em direção à fenda coberta pelo vidro
 63. 14,2 μm mais próximo
 65. a. 376 nm b. 1320 c. 1320
 67. a. Escuro b. 1,597
 69. 12,0 μm
 71. b. 0,022°, 0,058°
 73. a. -11,5°, -53,1°
 75. a. 0,52 mm b. 0,074° c. 1,3 m

Capítulo 23

1. a. 3,3 ns b. 0,75 m, 0,667 m, 0,458 m
 3. 8,0 cm
 5. 5,4 m
 7. 9,0 cm
 9. 42°
 11. 433 cm
 13. 35°
 15. 1,37
 17. 76,7°
 19. 3,2 cm
 21. 1,52
 23. a. $n_{\text{vermelho}} = 1,572$, $n_{\text{azul}} = 1,587$ b. 1,1
 25. 1580 nm
 27. Invertida
 29. Direita
 31. 68 cm
 33. 200 cm
 35. 1,5 cm
 37. Invertida
 39. Direita
 41. a. 3 b. B: (+1 m, -2 m), C: (-1 m, +1 m), D: (+1 m, +2)
 43. 10 m
 45. 42°
 47. 82,8°
 49. a. Do fundo b. 60 cm
 51. 4,7 m
 53. a. No fundo
 55. 1,552
 57. a. 17,9° b. 27,9°
 59. 3,0 cm
 61. b. $s' = 40$ cm, $h' = 2,0$ cm
 63. b. $s' = -60$ cm, $h' = 8,0$ cm
 65. b. $s' = -8,6$ cm, $h' = 1,14$ cm
 67. $s' = -30$ cm, $h' = 1,5$ cm, atrás e direita
 69. $f = 44$ cm a 67 cm da parede
 71. a. 4,0 cm b. 25 cm c. 3,4 cm
 73. 20 cm
 75. 13,3 cm
 77. a.

s (cm)	s' (cm)	h (cm)	h' (cm)
50	50	10	10
75	37,5	10	5,0
100	33,3	10	3,3
125	31,3	10	2,5
150	30	10	2,0



c. A imagem é curva e não paralela ao eixo.

79. a. $\frac{1}{f} = \frac{(n_2 - n_1)}{n_1} \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$ b. $f_{\text{ar}} = 40$ cm, $f_{\text{água}} = 156$ cm
 81. a. 23,6 cm c. 7,5 cm

Capítulo 24

1. b. $s'_2 = 49$ cm, $h'_2 = 4,6$ cm
 3. b. $s'_2 = 10$ cm, $h'_2 = 2,0$ cm
 5. b. $s'_2 = -3,33$ cm, $h'_2 = 0,66$ cm
 7. 5,0
 9. 6,0 mm
 11. 6,0 mm
 13. a. Miopia b. 100 cm
 15. 3,6°
 17. 5,0 cm
 19. 13 mm
 21. a. 40 b. 5,0
 23. 55 km
 25. 0,49
 27. Sim, 5,0 cm à direita da lente
 29. a. 3,75 cm c. 0,10 rad d. 2,5
 31. a. $f_2 + f_1$ b. $f_2/|f_1|$
 33. a. -f
 35. 23 cm
 37. 5,0 cm
 39. a. +3,0 D para a objetiva b. -1,5 c. 0,56 m
 41. a. 1,1 cm b. -160
 43. 2,6 cm
 45. 0,069 mm
 47. a. 3,8 cm b. O Sol é brilhante demais
 49. 165 MB
 51. 3,5 m
 53. b. 2,5

Capítulo 25

1. 410,3 nm, 389,0 nm, 379,9 nm
 3. 8
 5. 64°
 7. 4
 9. $1,2 \times 10^5$ J
 11. $2,0 \times 10^{-16}$ J
 13. a. $1,1 \times 10^{-34}$ m b. $1,7 \times 10^{-23}$ m/s
 15. a. $3,6 \times 10^6$ m/s b. $2,0 \times 10^3$ m/s
 17. 0,20 nm
 19. a. 121,6 nm, 102,6 nm, 97,3 nm, 95,0 nm b. 91,18 nm c. 31,4 cm
 21. a. $2,0 \times 10^{-12}$ m b. $2,5 \times 10^5$
 23. a. $3,1 \times 10^{-19}$ J b. $3,2 \times 10^{15}$
 25. 18,7°, 50,8°, 71,6°
 27. b. 2,4 nm, 1,2 nm
 29. a. 0,818 μm b. $1,1 \times 10^3$ m/s
 31. 170 m/s
 33. a. $E_1 = 1,2 \times 10^{-19}$ J, $E_2 = 4,9 \times 10^{-19}$ J, $E_3 = 1,1 \times 10^{-18}$ J b. $3,7 \times 10^{-19}$ J c. 540 nm
 35. 1,3 nm
 37. 29 fm
 39. a. $v_n = \frac{hn}{2mL}$ $n = 1, 2, 3, \dots$ b. $1,82 \times 10^6$ m/s, $3,64 \times 10^6$ m/s, $5,46 \times 10^6$ m/s
 41. a. 72,5°, 53,1°, 25,8° b. 64,9°, 31,9° c. 19,9°, 76,9°
 43. a. 10,0 nm, 5,00 nm, 3,33 nm, 2,50 nm b. $7,28 \times 10^4$ m/s, $1,46 \times 10^5$ m/s, $2,18 \times 10^5$ m/s, $2,91 \times 10^5$ m/s