Appendix: answers to questions

Chapter 1 Built environment

10. t_r 15.0°C; t_{ei} 16.3°C. The room condition is below the comfort zone shown in Fig. 1.14. Surface temperatures are to be increased by adding thermal insulation, such as double glazing, and the air temperature should be raised.
11. 90 W.
12. 6211 W, work bench overheating.
13. 640 W.
14. 17.6°C.
15. 1.6°C.
16. 17.6°C.
17. 982, −11.2°C.
18. 923, −8.5°C.
19. 1139, −18.3°C.
20. Site A *WCI* 862, *EWCT* −5.8°C; Site B *WCI* 757, *EWCT* −1°C; site A has the more severe conditions.
21. *HSI* −26.8.
22. *HSI* 96.0; this is the maximum 8-h exposure for a fit, acclimatized young person; conditions vary through the day.
23. *HSI* 288, *AET* 11.7 min.
24. *HSI* 67.4, *AET* −12.7 min unrestricted.
25. *HSI* 648, *AET* 8.8 min.
26. t_r 14.3°C; t_{ei}17.2°C. The room condition is outside the sedentary comfort zone.
27. 17.9°C, 17.2°C, 19.3°C, 20.3°C.
28. 13°C, 11.3°C, 15.7°C, 20°C.
29. 16.8°C, 15.4°C, 19.2°C, 21.4°C.
34. 2, 4
35. 1, 2, 4, 5
36. 3, 4
37. 2, 3, 5
38. 1, 2, 3, 4, 5
39. 2
40. 1, 2, 3, 4

45. 345 W.
47. C_i 0.977 decipol, C_o 0.3 decipol for vitiated outdoor air, Q 1770 l/s total, N 3.5 air changes/hour.
48. 1.47 l/s m^2.
49. 288 l/s m^2.
50. 0.33 l/s m^2.
51. 6.48 air changes/h.
52. 2.15 air changes/h.
53. $Q = 0.665$ air changes/h, no.
54. Answers in l/s. First figure is based on floor area, second is per person: Fanger 6250, 5000; ASHRAE 875 700; BS 1625, 1300; DIN 2375, 1900; CIBSE 1625, 1300; maximum N 5.1 air changes/hour.
55. C_1 0.612 decipol, G 0.517 olf/m^2, C_o 0.05 decipol, Q 9.2 l/s m^2, total Q 2760 l/s, N 6.6 air changes/hour.
61. 2, 4, 5
62. 3
63. 1, 4
64. 3
65. 1, 4
66. 4
67. 3
68. 2
69. 5
70. 3
71. 4
72. 5

Chapter 2 Energy economics

11. U_e 0.51 W/m^2K, L 53 mm.
12. A_f 2640 m^2, A_w 1776 m^2, B 1.035, T_T 8.46 W/m^2, T_E 24.85 W/m^2, T 33.3 W/m^2.
13. Gas 110, oil 158, coal 215, electric 224 tonnes C p.a.
14. 3
15. 2
16. 4
17. 1
18. 5
19. 4
20. 4
21. 1
22. 4
23. 1
24. 2
25. 2
26. 5
27. 2
28. 5
29. 5

Chapter 3 Heat loss calculations

4. 2330.5 W.
5. 20.112 kW.
6. 12.4°C.
7. Allowed heat loss per degree Celsius difference inside to outside is 3746.8 W/K; thus the proposal complies. Proposed heat loss 3407 W/K.
8. 83.14 kW.
9. 43%.
13. R_{si} 0.1 m^2K/W, Q 50 W, U 2.78 W/m^2K, R_n 6.67 m^2K/W, 221 mm.
14. R_{si} 0.12 m^2K/W, Q 19.2 W, 114, 120 mm used, U_n 0.29 W/m^2K, 17.4°C.
15. R_{si}0.1 m^2K/W, Q 20 W, U 1.82 W/m^2K, extra R_a 0.18 m^2K/W; 81.75, 90 mm used, U_n 0.23 W/m^2K, new Q 4.83 W, 15.5°C.
16. 2, 3
17. 4
18. 2
19. 5
20. 4
21. 5
22. 5
23. 2
24. 2
25. 2
26. 3
27. 3
28. 5
29. 4
30. 4

Chapter 4 Heating

11. 0.95 l/s.
12. 2.4 m long × 700 mm high.
13. X 42 mm, Y 35 mm, Z 28 mm, radiator 1 22 mm, radiator 2 28 mm.
14. Expected internal temperature 26.5°C, system performance is satisfactory.
17. 3
18. 3
19. 4
20. 1
21. 2
22. 1
23. 3
24. 3, 5, 6, 7, 9
25. 2
26. 3
27. 3
28. 2
29. 5
30. 3

31. 3, 5
32. 3
33. 3
34. 4
35. 2
36. 2
37. 4
38. 4
39. 3
40. 5
41. 2
42. 5
43. 2
44. 3
45. 4
46. 3
47. 3
48. 2
49. 5
50. 3
51. 2
52. 4
53. 3
54. 5
55. 3
56. 5
57. 3

Chapter 5 Ventilation and air conditioning

1. From

$$Q = \frac{\text{SH kW}}{t_r - t_s} \times \frac{(273 + t_s)}{357}\ \text{m}^3/\text{s}$$

$$357Q\,(t_r - t_s) = \text{SH}(273 + t_3)$$

$$357Qt_r - 357Qt_s = 273\text{SH} + \text{SH} \times t_s$$

$$357Qt_r - 273\text{SH} = \text{SH} \times t_s + 357Qt_s$$

$$357Qt_r - 273\text{SH} = t_s(\text{SH} + 357Q)$$

and

$$t_s = \frac{357Qt_r - 273\text{SH}}{\text{SH} + 357Q}$$

$$= \frac{357 \times 5 \times 23 - 273 \times 50}{50 + 357 \times 5} = 14.94°\text{C}.$$

2. 0.793 m^3/s.

4. 0.007469 kg H_2O/kg air.
5. (a) No; (b) 21.2°C w.b.; 0.877 m^3/kg; (c) 6.186 kW.
6. (a) 4.25 m^3/s; (b) 4.86 m^3/s; (c) 87.45%; (d) 4.13 m^3/s; (e) 0.61 m^3/s; (f) 3.52 m^3/s.
7. 20 air changes/h.
14. 1680 mm × 930 mm.
16. 2.68 m^3/s, 10.72 air changes/h, 0.0076 kg H_2O/kg air.
17. t_s 28.6°C d.b., reduce supply air quantity to 1.7 m^3/s and use t_s, 30°C d.b. if the room air change rate will not be less than 4 changes/h.
21. 14.45 air changes/h.
22. 15 air changes/h, 710 mm × 710 mm, 2 m^3/s fresh air, 2 m^3/s recirculated air, 3.6 m^3/s extract air, 4 m^3/s supply air duct, 0.4 m^3/s natural exfiltration.
23. 4
24. 5
25. 2
26. 2
27. 1
28. 2
29. 5
30. 5
31. 3
32. 4
33. 2
34. 4
35. 1
36. 2
37. 4
38. 4
39. 5
40. 3
41. 1
42. 4
43. 1
44. 3
45. 2
46. 5
47. 3
48. 3, 4
49. 2, 4
50. 1, 5
51. 1, 3, 4
52. 3
53. 5
54. 2
55. 1
56. 5
57. 4
58. 5
59. 5
60. 4

61. 4
62. 5
63. 4
64. 4
65. 2
66. 3
67. 1
68. 3
69. 4
70. 4
71. 2
72. 1
73. 3
74. 3
75. 1
76. 3
77. 3
78. 3
79. 1
80. 5
81. 1
82. 4
83. 4
84. 3
85. 4
86. 3
87. 5
88. 4
89. 2
90. 4
91. 1
92. 5
93. 1

Chapter 6 Hot- and cold-water supplies

12. 13.44 kW.
15. 0.56 h.
16. 0.05 kg/s, 3.15 m head, pump C.
23. 3
24. 4
25. 3
26. 5
27. 5
28. 5
29. 5
30. 1
31. 1

32. 5
33. 5
34. 3
35. 5
36. 1
37. 5
38. 4
39. 5
40. 1
41. 5
42. 5
43. 3
44. 2
45. 5
46. 3
47. 1
48. 5
49. 4
50. 4
51. 4
52. 5
53. 5

Chapter 7 Soil and waste systems

7. The furthest WC can only be 12.353 m from the stack.
8. 53
15. 5
16. 5
17. 4
18. 3
19. 1
20. 2
21. 5

Chapter 8 Surface-water drainage

2. 50 l/s, at least three.
3. 5.04 l/s.
4. 1.337 l/s.
5. 1.45 l/s.
6. 35.53 l/s.
7. 2.921 l/s. Note that this is less than the figure given in Table 8.2 because of the simplifying assumptions made here.
8. Either 125 mm with centre outlet or 150 mm with end outlet.
9. Width *W* 120 mm, depth *D* 71.876 mm.
10. Yes, flow load 2.1 l/s, gutter capacity 2.936 l/s.
12. Storage volume 2.4 m^3, one pit diameter 1.25 m.

Chapter 9 Below-ground drainage

3. 100 mm.
4. 150 mm.
5. 1.235 m.
6. 225 mm, approximately 614.
13. 3
14. 5
15. 5

Chapter 10 Condensation in buildings

15. (a) 6.79°C, 6.11°C; (b) 13.89°C, 13.55°C, 2.89°C, 2.55°C; (c) 18.47°C, 17.83°C, 6.71°C, 2.91°C, 0.27°C; (d) 19.45°C, 19.06°C, −0.38°C.
16. 2.72°C.
17. −7.46°C.
18. 28.1 mm.
19. *U* value 0.46 W/m^{2}K, heat flow 9.26 W/m^2. Thermal temperature gradients are 22°C, 21.07°C, 20.38°C, 18.71°C, 11.76°C, 3.08°C, 2.9°C, 2.7°C, 2°C. Indoor dew-point 11.3°C, vapour pressure 1300 Pa, outdoor air −0.8°C and 568 Pa. Vapour resistance R_V 6.265 GN s/kg, mass flow of vapour *G* 1.168 × 10^{-7} kg/m^{2}s. Dew-points at the same interfaces as the thermal temperatures are 11.3°C, 11.3°C, 10.5°C, 10.5°C, 8.8°C, −0.7°C, −0.8°C, −0.8°C, −0.8°C. Condensation does not occur.
20. *U* value 0.6 W/m^{2}K, heat flow 7.74 W/m^2. Thermal temperature gradients are 14°C, 13.07°C, 12.84°C, 11.32°C, 3.58°C, 2.19°C, 1.22°C, 1°C. Indoor dew-point 6.5°C, vapour pressure 936 Pa, outdoor air −1.8°C and 531 Pa. Concrete block work resistivity taken as 200 GN s/kg m. Vapour resistance R_V 25.35 GN s/kg, mass flow of vapour G 1.6 x 10^{-8} kg/m^{2}s. Dew-points at the same interfaces as the thermal temperatures are 6.5°C, 6.5°C, 6.3°C, 0.09°C, −0.06°C, −0.06°C, −1.8°C, −1.8°C. Condensation does not occur.
21. 3
22. 4
23. 5
24. 3
25. 4
26. 1
27. 3
28. 4
29. 3
30. 1
31. 3
32. 4

Chapter 11 Lighting

9. 59%.
11. Room index 3, *UF* 0.73, *MF* 0.9, 36 luminaires in 3 rows of 12 along the 20 m dimension, 16.8 W/m^2, 21 A.
22. Lighting 3750 h/year, 3.81 × 10^6 lm, tungsten, 1814 lamps, replace 3401 per year, total annual cost £80 255 per year, fluorescent 569 lamps, replace 178 per year, total annual cost £14 403 per year, sodium 139 lamps, replace 22 per year, total annual cost £10 917 per year.

23. Lighting 1200 h/year, 35 0685 lm, tungsten 352 lamps, replace 211 per year, total annual cost £3559 per year, fluorescent 95 lamps, replace 16 per year, total annual cost £772 per year, halogen 37 lamps, replace 2 per year, total annual cost £423 per year.
24. 1
25. 4
26. 1
27. 1, 3, 5
28. 3
29. 4
30. 2
31. 3
32. 1
33. 3, 5
34. 4
35. 3
36. 1
37. 2
38. 3
39. 5
40. 4
41. 4
42. 2
43. 3
44. 3
45. 4
46. 2
47. 2
48. 3
49. 4
50. 5

Chapter 12 Gas

1. 1.026 l/s, 125 mm H_2O.
2. 5.394, 3.5, 0.75, 15, 1050 mb.
3. 3.333 Pa/m.
4. 27.17 m.
5. 1.47 l/s, 2.609 Pa/m, 32 mm.
6. 72 Pa.
11. 4, 5
12. 3
13. 1

Chapter 13 Electrical installations

5. 0.00172 Ω.
6. 0.2867 Ω.
7. 10.7%.
10. 12.6 kVA.
11. 19.2 Ω.

12. 0.2857 mA.
14. 9716.8 kW.
15. 28.6 m.
16. (i) 18.25 kVA, 25.4 A, (ii) £691.95.
26. Three earth rods give a total system resistance of 8.937 Ω.
27. 2, 4, 5
28. 5
29. 3
30. 1, 5
31. 4
32. 2, 4
33. 4, 5
34. 5
35. 1
36. 3
37. 5
38. 4
39. 1
40. 5
41. 2
42. 4
43. 1
44. 5
45. 2
46. 5
47. 3
48. 5
49. 5
50. 4
51. 4
52. 2
53. 2
54. 4
55. 2
56. 1

Chapter 14 Room acoustics

19. Reverberation time *T* 2.901 s at 125 Hz, 3.462 s at 250 Hz, 3.462 s at 500 Hz, 3.157 s at 1 kHz, 2.752 s at 2 kHz and 3.253 s at 4 kHz.
20. *r* 100 mm *SPL* 87 dB; *r* 1 m *SPL* 71 dB.
21. Directivity *Q* 2, *r* 0.5 m *SPL* 92 dB, reverberant *SPL* 79 dB.
22. 84 dBA.
23. Through the wall $SPL_2$19 dB; through air vent 49 dB; open air vent causes noise to bypass the attenuation of the wall and may need acoustic louvres or an acoustic barrier.
24. Through the wall SPL_2 47 dB; through air vents in doors 59 dB; open air vent causes noise to bypass the attenuation of the wall; burner needs an acoustic enclosure.
25. *SPL* in roof is 32 dB; the large volume and short reverberation time assist in attenuating the plant room noise.
26. 33 dB.

27. 37 dB.
28. 39 dB.
29. See chapter explanation.
30. *NR* 40 is not exceeded in the room.
31. (a) *NR* 80; (b) *NR* 25, no intrusive noise from the chiller; (c) *NR* 45; (d) *NR* 20 when doors have equal sound reduction to the walls, have air-tight seals and are closed.
32. (a) *NR* 80; (b) 65 dB due to sound escape through door; (c) *NR* 35.
33. (a) *NR* 75; (b) *NR* 45, equivalent to the background noise level in a corridor; (c) *NR* 35; (d) *NR* 20, there is no intrusive noise.
34. (a) *NR* 60; (b) *NR* 40; (c) through the supply and return air ducts, noise radiation from the outer case of the fan coil unit, from the ceiling space through ceiling tiles, light fittings, noise break-in from the ceiling space into the supply and return air ducts and then into the office, structurally transmitted vibration from the fans, main air-handling plant noise through the outside air duct to the fan coil unit; (d) acoustic lining in the outdoor air, supply air and return air ducts, anti-vibration rubber mounts for the fan coil unit and the fan within it, acoustic lining within the fan coil unit, acoustic blanket above the recessed luminaires and above the ceiling tiles.
35. 3
36. 1
37. 3
38. 3
39. 5
40. 3
41. 3
42. 4
43. 5
44. 1
45. 4
46. 5
47. 5
48. 3
49. 5
50. 3
51. 5
52. 4
53. 4
54. 2
55. 1
56. 5
57. 3
58. 5
59. 2

Chapter 15 Fire protection

10. 2, 3, 5
11. 4
12. 2, 3
13. 1, 2, 3, 4, 5

14. 1, 2, 3, 4, 5
15. 3
16. 1, 2, 3, 4, 5
17. 5
18. 4
19. 3
20. 5
21. 1

Chapter 16 Plant and service areas

10. 5
11. 3
12. 1
13. 4
14. 2
15. 3
16. 2
17. 4
18. 2
19. 5
20. 2

Chapter 17 Mechanical transport

16. 1, 2, 4, 5
17. 2, 5
18. 3
19. 3, 4
20. 5
21. 3
22. 2

Chapter 18 Question bank

1. 4
2. 2
3. 4
4. 2
5. 5
6. 3
7. 3
8. 4
9. 3
10. 4
11. 3
12. 5
13. 3
14. 1, 2, 4, 5

15. 5
16. 2
17. 5
18. 5
19. 1
20. 4
21. 5
22. 5

Chapter 19 Understanding units

1. 4
2. 4
3. 2
4. 3
5. 5
6. 3
7. 4
8. 5
9. 4
10. 5
11. 4
12. 3
13. 4
14. 5
15. 5
16. 2
17. 5
18. 4
19. 5
20. 4
21. 5
22. 1
23. 1
24. 4
25. 3
26. 2
27. 1
28. 2
29. 5
30. 2
31. 3
32. 3
33. 5
34. 2
35. 5
36. 4
37. 3
38. 3

39. 3
40. 5
41. 1
42. 5
43. 3
44. 3
45. 1
46. 4
47. 1
48. 4
49. 3
50. 5