CHAPTER 1

Test your knowledge

1 c – Your employer
2 d – PUWER
3 b – Mobile tower scaffold
4 a – To ensure that all operatives are aware of the safety procedures on-site
5 a – Mandatory
6 b – Class B
7 b – Yellow
8 b – 1.2 m
9 c – When exceeding 2.0 m
10 d – An injury that results in more than 24 hours’ hospitalisation
11 ‘It is the duty of every employer, so far as is reasonably practicable, to ensure the health, safety and welfare at work of their employees.’
12 A permit to work is a document put together by those authorising the work and those carrying it out, which gives authorisation for named persons to carry out specific work within a nominated time frame.
13 There is no particular ‘most dangerous’ type of asbestos. Although some may carry more risk due to their ability to become more friable, such as blue asbestos, in general all asbestos should be treated with the same precautions. Identifying asbestos by sight alone is very difficult and specialist testing is required to classify its type, therefore all suspected materials should be treated in the same way.
14 Your answer should have included six of the following: flue pipes, gutters, soil and vent pipes, pipe insulation, boiler gaskets, cold water cisterns, Artex, roof and floor tiles, plaster, soffit boards.
15 Safe manual lifting uses the strength of larger muscle groups and the skeletal frame; it is termed kinetic lifting. Correct kinetic lifting avoids overuse of the back, which may cause strain. Correct kinetic lifting instead requires comfortable postures and a straight back.

CHAPTER 2

Test your knowledge

1 d – 7.0 mm SDS bit
2 b – To remove an immersion heater
3 d – BS EN 1057
4 b – 95 mm
5 b – Medium
6 d – MDPE
7 a – 65 mm
8 c – 25% of the depth of the joist
9 a – 1.8 m
10 c – 1.2 m
11

<table>
<thead>
<tr>
<th>Colour</th>
<th>No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yellow</td>
<td>4–10</td>
</tr>
<tr>
<td>Red</td>
<td>6–12</td>
</tr>
<tr>
<td>Brown</td>
<td>10–14</td>
</tr>
<tr>
<td>Grey</td>
<td>8–12</td>
</tr>
<tr>
<td>White</td>
<td>10–14</td>
</tr>
<tr>
<td>Blue</td>
<td>10–14</td>
</tr>
</tbody>
</table>
12 300 mm × 0.125 = 37.5 mm
13 R220 fully annealed copper pipe
14 Three from Water Supply (Water Fittings) Regulations, Building Regulations, Gas Safety (Installation and Use) Regulations, HASAWA 1974, Electricity at Work Act
15 Press-fit

Activities

Answers to ‘Improve your maths’ activity, page 95:

1 6 × 15 × 1.57 = 141.3 mm
2 4 × 22 × 1.57 = 138.16 mm
3 5 × 22 × 1.57 = 172.7 mm

Answers to ‘Improve your maths’ activity, page 122:

1a 315 mm to 1125 mm
1b 25 mm
2a 210 mm to 750 mm
2b 31.25 mm
3a 252 mm to 900 mm
3b 37.5 mm
Answers to 'Maths' activity, page 123:

- a 1125 mm to 1800 mm
- b 50 mm

### CHAPTER 3

**Test your knowledge**

1. c – 340.0 N/m²
2. a – kg
3. a – 22 mm end feed elbow
4. a – Its ability to be stretched without breaking
5. d – 240 m³
6. a – Joule
7. a – Voltage
8. b – 187.5 volts
9. d – 10 mm²
10. d – Electrolytic
11. 31,350 kJ
12. 0.35 bar
13. 

<table>
<thead>
<tr>
<th>Measure of:</th>
<th>SI unit</th>
<th>Symbol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Area</td>
<td>Square metre</td>
<td>m²</td>
</tr>
<tr>
<td>Volume</td>
<td>Cubic metre</td>
<td>m³</td>
</tr>
<tr>
<td>Velocity</td>
<td>Metres per second</td>
<td>m/s</td>
</tr>
<tr>
<td>Density</td>
<td>Kilogram per cubic metre</td>
<td>kg/m³</td>
</tr>
</tbody>
</table>

14. 3 m × 70°C × 0.000016 = 0.00336 m (3.3 mm)
15. Wheelbarrow, Crowbar

### Activities

Answers to 'Maths' activity, page 149:

1. 25 × 4.5461 = 113.65 litres
2a 8 × 0.3048 = 2.4384 m
   11 × 0.3048 = 3.3528 m
2b 2.438 × 3.3528 = 8.174 m²

Answer to 'Maths' activity, Example 1, page 172:

35748 kJ

Answer to 'Maths' activity, Example 2, page 172:

4.96 kW

Answer to 'Maths' activity, Example 3, page 172:

1758.12 seconds, or 29 minutes and 20 seconds

Answer to 'Calculating force' activity, page 174:

981 newtons

Answer to 'Pressure' activity, page 175:

9810 N/m²

Answers to 'Static pressure of water' activity, page 175:

- a 160 kPa
- b 1.6 bar

Answer to Ohm's law Maths activity, Example 1, page 189:

27.27 amps

Answer to Ohm's law Maths activity, Example 2, page 189:

222.22 V

Answer to Ohm's law Maths activity, Example 3, page 190:

15.333 ohms

Answer to 'Series circuits' activity, page 192:

Since 1 bulb is 40 watts, 1 is 60 watts and 2 bulbs are 100, first use the formula below to find the amps for each bulb:

\[ I = \frac{P}{V} \] (from the power triangle) to find the amps (I) = \( \frac{\text{watts}}{\text{volts}} \)

\[ I = \frac{40}{230} = 0.1739 \text{ amps (I)} \]

\[ I = \frac{60}{230} = 0.2608 \text{ amps (I)} \]

\[ I = \frac{100}{230} = 0.4347 \text{ amps (I)} \]

To find the voltage supplied to each bulb:

\[ R_1 = \frac{V}{I} = \frac{110}{0.1739} = 632.54 \text{ ohms} \]

\[ R_2 = \frac{V}{I} = \frac{110}{0.2608} = 421.779 \text{ ohms} \]

\[ R_3 = \frac{V}{I} = \frac{110}{0.4347} = 253.048 \text{ ohms} \]
Test your knowledge and activities answers

Test your knowledge

1. b – The project involves 500 or more person-days or lasts more than 30 days
2. d – The quantity surveyor
3. b – The local authority
4. a – The specification
5. d – Notching joists to install heating pipework
6. a – To ensure that all work by contractors is completed in line with agreed plans and relevant standards on behalf of the client
7. d – Evaluate the risks and decide on precautions
8. b – Level 2
9. c – The supervisor
10. a – Increased labour costs
11. A positive approach could be to talk alone with the apprentice once the flooding problem is resolved and ask them where they think they made a mistake. An action plan, which could comprise a checklist for when they next carry out the same task, could be drawn up and agreed upon.

Three from:
- Give more verbal detail than you would usually use
- Describe any diagrams or visual aids you are using
- Keep the person informed of his or her surroundings
- Talk clearly and check that the customer has an understanding

13. The H&S inspector, the building control inspector, the water inspector, the electrical services inspector

14. The Advisory, Conciliation and Arbitration Service (ACAS) is an organisation that provides free and impartial information and advice to employers and employees on all aspects of workplace relations and employment law.

15. Likelihood × Consequence = Risk factor

CHAPTER 4

Test your knowledge

1. b – The project involves 500 or more person-days or lasts more than 30 days
2. d – The quantity surveyor
3. b – The local authority
4. a – The specification
5. d – Notching joists to install heating pipework
6. a – To ensure that all work by contractors is completed in line with agreed plans and relevant standards on behalf of the client
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 CHAPTER 5

Test your knowledge

1. b – 5
2. a – 4
3. d – Grey water
4. a – Sedimentation
5. a – BS EN 806
6. b – 25 mm
7. b – 230 litres
8. b – Part 2
9. c – On the incoming water main as it enters the property
10. d – AUK3
11. Fluid category 2 is water that would normally be classified as fluid category 1 but whose aesthetic quality has been impaired because of:
- a change in temperature
- a change in appearance, taste or odour owing to the presence of substances or organisms.

An example of this may be water that has been heated and stored within a domestic hot water cylinder.

12. Two from:
- reduced water consumption within the property
- lower water bills
- reduced localised flooding.
13

<table>
<thead>
<tr>
<th>Particular advantage</th>
<th>Indirect system</th>
<th>Direct system</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cheaper to install</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Drinking water to all fittings</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Less fluctuation of pressure during peak demand periods</td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Less risk of leaks due to lower pressures</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Smaller pipe sizes may be used</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Good pressure at all outlets</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Less risk of backflow</td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

14 To prevent pumps running dry, the break cistern should be sized to cope with 15 minutes of constant pumping without emptying the cistern below the outlet feeding the pumps. A low-level limit switch should also be positioned to avoid the pumps running when the water level drops to within 225 mm of the suction connection feeding the pumps.

15 A true mixer tap allows the hot and cold water to mix within the body of the tap, which means in theory that cross-connection can be an issue. A bi-flow mixer has a spout that is divided down the middle so that the water does not mix until it has left the outlet.

Activities

Answers to margin ‘Maths’ activity, page 331:
1 38 m = 3.8 bar
2 4.5 bar = 450 kPa
3 150 kPa = 1.5 bar

Answers to ‘Maths’ activity, page 331:
1 30 l/m = 0.5 l/s
2 0.25 l/s = 15 l/m
3 12 l/m = 0.2 l/s
4 0.12 l/s = 7.2 l/m

CHAPTER 6

Test your knowledge

1 b – 55°C
2 b – Part G
3 a – Under-sink single point heater
4 c – Open vent a minimum of 22 mm diameter connected within 450 mm of the draw-off connection from the cylinder
5 d – 100°C
6 a – A quarter of the way down
7 d – 1: Isolation valve; 2: Strainer; 3: Pressure reducing valve; 4: Check valve
8 d – 95°C
9 c – TMV3
10 b – 22 mm
11 A: Indirect system with double feed indirect cylinder. B: Indirect system with single feed self-venting (Primatic) cylinder. C: Direct system
12 The secondary return allows for a quicker delivery of hot water at outlets. This is possible as the hot water distribution is circulated by a pump and brought back to the cylinder for reheating. The water is therefore maintained at a minimum of 55°C throughout its distribution, which prevents excessive running of the hot water tap. Dead legs are therefore prevented, which reduces the risk of bacterial growth.
13 Single impeller, twin impeller
14 100 litres
15 To prevent galvanic or electrolytic corrosion

Activities

Answers to ‘Maths’ activity, page 370:
1 74.229 litres
2 106.828 litres
3 294.5 litres

Answers to ‘Maths’ activity, page 371:
1 390 mm
2 270 mm
3 5 m
Answer to 'Maths' activity, page 400:
3 bar

Answer to 'Maths' activity, page 404:
28 mm

Answers to 'Maths' activity, page 414:
1 \[6 \times 50 \times 0.00018 = 0.054\] or 54 mm
2 \[20 \times 35 \times 0.00016 = 0.0112\] or 11.2 mm
3 \[30 \times 44 \times 0.00016 = 0.02112\] or 21.12 mm

CHAPTER 7

Test your knowledge

1 b – 20°C
2 b – Open vent pipe
3 d – The 'S' Plan
4 a – Hot water only
5 c – C
6 c – Condensing boiler
7 b – 150 mm
8 d – Expansion vessel
9 a – Independent time-controlled zones
10 a – Underfloor heating manifold

11 The boiler interlock is not a single control device but the interconnection of all of the controls on the system, such as room thermostats, cylinder thermostats and motorised valves. The idea behind the boiler interlock is to prevent the boiler firing up when it is not required.

12 Fully pumped systems with mid-position valve (commonly referred to by the Honeywell trade name Y-Plan); fully pumped systems with 2 × two-port valves (commonly referred to by the Honeywell trade name S-Plan).

13 Corrosion inhibitor must be added to the system to comply with the manufacturer’s warranty. Corrosion inhibitor slows down the process of corrosion and black sludge forming, and helps to lubricate pump bearings and valves. Once added, corrosion inhibitor does not need to be replaced, except when the system is drained down.

14 The connection of a heating system to the mains cold water supply constitutes a cross-connection between the cold main (fluid category 1) and the heating system (fluid category 3), which is not allowed under the Water Supply (Water Fittings) Regulations.

15 Drain valves should be fitted at the lowest points within the system, to allow for full draining.

CHAPTER 8

Test your knowledge

1 b – Rainfall intensity, roof area, gutter fall
2 c – Discharge water on the roof with a hosepipe
3 c – Ogee
4 a – 2 mm/m
5 c – 36 mm
6 b – Document H
7 d – 1000 mm
8 d – Hopper
9 b – MDPE
10 a – BS EN 12056–3:2000
11 126 m²
12 A 10 mm space for expansion is provided in all fittings such as running outlets.

13 104 × 0.022 = 2.28 l/s

14 Answers from:
- It is strong and durable
- It is lightweight
- Long lengths can be installed
- Fewer leaks than cast iron
- A variety of profiles and colours
- Minimal thermal expansion

15 Hacksaw, hammer, string line/plumb line, bradawl, file/rasp, cordless drill and screwdriver

Activities

Answers to 'Calculation of effective roof area' activity, page 528:

1 102 m²
2 80 m²
3 100 m²

Answers to 'Calculation of effective roof area using pitch factors' activity, page 529:

1 126 m²
2 119.68 m²
3 103.2 m²
Answer to ‘Calculation of rainfall rate in litres per second’ activity, page 529:
1 2.62 l/s
2 2.48 l/s
3 2.14 l/s

Answers to ‘Calculation of thermal expansion’ activity, page 532:
1 \(10 \times 15 \times 0.06 = 9\) mm
2 \(20 \times 30 \times 0.06 = 36\) mm
3 \(5 \times 20 \times 0.06 = 6\) mm

CHAPTER 9

Test your knowledge
1 b – Part H
2 d – 38 mm
3 b – 50 mm
4 b – 3 m
5 c – 900 mm
6 d – Washing machine trap
7 a – Compression
8 c – 200 mm
9 a – BS 6465–2
10 d – Capillary action
11 Cast iron baths are very heavy, therefore the risk of back injury through lifting is realistic. Where possible, baths should be broken into smaller pieces; this in turn carries a risk of flying debris such as glass enamel. Damage to hearing is also possible when breaking the cast.
12 6 litres for long flush, 4 litres for short flush
13 An air admittance valve allows air into a stub stack to prevent the loss of trap seals. The suction action when an appliance is used opens the valve. This stabilises the condition of the air in the stack as air is sucked into the stack through the valve, which has the secondary effect of not letting smells or foul air out.
14 Three from:
- The valve operates silently; this eliminates the noises generally associated with water-filled traps
- The valve allows a greater number of appliances to be installed on the same discharge system without the risk of compromising system efficiency
- The valve can withstand back pressures equivalent to ten times greater than those experienced in a typical sanitary pipework system
15 20 mm/m

Activities
Answers to ‘The gradient curve’ activity, page 552:
1 20 mm/m
2 70 mm/m
3 0.6 m

Answers to ‘Calculation of thermal expansion’ activity, page 609:
1 13.5 mm
2 18 mm
3 6 mm

CHAPTER 10

Test your knowledge
1 b – \(\text{C}_3\text{H}_8\)
2 a – 38 MJ/m\(^3\)
3 b – Anthracite
4 c – Part J
5 d – 110% of the volume of the tank
6 c – HETAS
7 d – 1800 mm
8 a – CO
9 a – C
10 a – 0.6
11 Natural gas, LPG, oil, solid fuel and biomass fuels
12 Mercaptan
13 Five from:
- Availability
- Appliance type
- Storage requirements
- Environmental considerations
- Smoke control legislation
- Cost
- Client preference
14 Gas Safe is the UK registration body for the installation, maintenance and repair of gas installations and appliances. By law, all operatives engaging in domestic natural gas and LPG installations must be registered with Gas Safe and must hold various qualifications within the gas industry.

15 Combined heat and power is a plant where electricity is generated and the excess heat generated is used for heating. It is used primarily for district heating systems but micro-CHP has also been developed for domestic properties.