

**Solution Manual for Refrigeration and Air Conditioning  
Technology 8th Edition Tomczyk Silberstein Whitman Johnson  
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## Unit

## 2

This unit defines matter, mass, density, specific gravity, and specific volume. Gas laws, including Boyle's law, Charles' law, the general law of perfect gas, and Dalton's law, are stated. The broad subject of energy is covered, as well as energy in heat and in magnetism. The measurement of energy in horsepower, watts, and British thermal units is discussed. Unit review questions, key terms in the *Lab Manual and Workbook*, and *Lab Manual and Workbook Review Test* questions may be used, as discussed in Unit 1.

### OBJECTIVES

After studying this unit, the student should be able to:

- .. define matter.
- .. list the three states in which matter is commonly found.
- .. define density.
- .. discuss Boyle's law.
- .. state Charles' law.
- .. discuss Dalton's law as it relates to the pressure of different gases.
- .. define specific gravity and specific volume.
- .. state two forms of energy important to the HVAC/R industry.
- .. describe work and state the formula used to determine the amount of work done by performing a given task.
- .. define horsepower.
- .. convert horsepower to watts.
- .. convert watt-hours to British thermal units.

### SAFETY Checklist

- .. Power-consuming devices have the potential to cause injury. Be sure to de-energize all pumps, motors and other electrical devices before working on them.
- .. When measuring pressures, be sure that your test instruments are fully operational and properly calibrated to avoid possible injury.

### EXERCISES (LAB MANUAL)

Exercises 2-1, 2-2, and 2-3

# Matter and Energy

## UNIT 2 ANSWERS TO REVIEW QUESTIONS (TEXT)

1. D.
2. Solid, liquid, and gas.
3. Ice.
4. Down.
5. Downward and outward.
6. D.
7. Weight per unit volume of a substance.
8. The density of a substance compared to the density of water.
9. The volume occupied by 1 pound of a fluid.
10. The moon has less mass than the earth, thus its gravitational pull is weaker.
11. Specific volume  $5 \frac{1}{1210} \text{ lb/ft}^3$   $5 \frac{0.000826}{1} \text{ ft}^3/\text{lb}$ .
12. Density  $5 \frac{1}{(0.001865 \text{ ft}^3/\text{lb})}$   $5 \frac{536.19}{1} \text{ lb/ft}^3$ .
13. Specific gravity  $5 \frac{171 \text{ lb/ft}^3}{62.4 \text{ lb/ft}^3}$   $5 \frac{2.74}{1}$ .
14. Density is  $(4 \text{ lb} / 10 \text{ ft}^3)$   $5 \frac{0.4 \text{ lb/ft}^3}{1}$ .  
Specific gravity is  $(0.4 \text{ lb/ft}^3 / 62.4 \text{ lb/ft}^3)$   $5 \frac{0.0064}{1}$ .
15. It describes how one gas reacts when mixed with another. For example, natural gas is lighter than air and rises; propane is heavier than air and falls. Specific volume must be considered when determining the size of compressors or vapor pumps. Specific volume of air also provides the HVAC/R system designer with information regarding how many pounds of air are being moved by blowers and fans.
16. B.
17. It will expand when heated or contract when cooled.
18. Dalton's law states that the total pressure of a confined mixture of gases is the sum of the pressures of each of the gases in the mixture.
19. Solar and fossil fuels.
20. From decaying animal and vegetable matter compressed below the earth's surface.
21. Power.
22. Force  $\times$  distance.
23.  $4 \text{ ft} \times 300 \text{ lb} = 1200 \text{ foot-pounds}$ .
24. An early expression of power, or the equivalent of raising 33,000 pounds to a height of 1 foot in one minute. Weight, height, and time.
25. 746 watts  $\approx$  1 horsepower.
26.  $(4 \text{ kW} \times 3413 \text{ Btu/kW}) = 13,652 \text{ Btu/h}$ .
27. 12,000 watts  $\approx$   $3.413 \text{ Btu/Wh} \times 40,956 \text{ Btu/h}$ .
28. Kilowatt hour.

29. The pressure is constant so  $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

$$V_2 = \frac{V_1 T_2}{T_1}$$

$$V_2 = \frac{(3000 \text{ ft}^3)(551.460)^\circ\text{R}}{(751.460)^\circ\text{R}} = 22887.8 \text{ ft}^3$$

30.  $\frac{P_1 V_1}{T_1} = \frac{P_2 V_2}{T_2}$

$$P_2 = \frac{P_1 V_1 T_2}{V_2 T_1}$$

$$P_2 = \frac{(10 \text{ psia})(14.696)(10.5 \text{ in}^3)(180^\circ\text{R})}{(651.460)^\circ\text{R}(1.5 \text{ in}^3)}$$

$$P_2 = 210.74 \text{ psia}$$

$$P_2 = (210.74 \text{ psia})(14.696) = 3096 \text{ psig}$$

### UNIT 2 ANSWERS TO REVIEW TEST QUESTIONS (LAB MANUAL)

- |       |       |        |        |
|-------|-------|--------|--------|
| 1. C. | 5. D. | 8. C.  | 11. D. |
| 2. A. | 6. A. | 9. C.  | 12. D. |
| 3. B. | 7. D. | 10. D. | 13. C. |
| 4. C. |       |        |        |

### COMPLETED CHART FROM EXERCISE 2-1

(Bolded values in parentheses represent the items that were to be filled in by the student.)

| Substance | Density (lb/in <sup>3</sup> ) | Density (oz/in <sup>3</sup> ) | Density (lb/ft <sup>3</sup> ) | Specific Gravity | Substance         |
|-----------|-------------------------------|-------------------------------|-------------------------------|------------------|-------------------|
| A         | <b>(0.7)</b>                  | <b>(11.2)</b>                 | 1208                          | <b>(19.36)</b>   | <b>(GOLD)</b>     |
| B         | <b>(0.036)</b>                | <b>(0.58)</b>                 | <b>(62.4)</b>                 | 1                | <b>(WATER)</b>    |
| C         | <b>(0.317)</b>                | <b>(5.07)</b>                 | <b>(548)</b>                  | <b>(8.78)</b>    | RED BRASS         |
| D         | 0.3218                        | <b>(5.15)</b>                 | <b>(556)</b>                  | <b>(8.91)</b>    | <b>(COPPER)</b>   |
| E         | <b>(0.033)</b>                | 0.5324                        | <b>(57.5)</b>                 | <b>(0.92)</b>    | <b>(ICE)</b>      |
| F         | <b>(0.099)</b>                | <b>(1.58)</b>                 | 171                           | <b>(2.74)</b>    | <b>(ALUMINUM)</b> |
| G         | <b>(0.70)</b>                 | <b>(11.2)</b>                 | <b>(1210)</b>                 | <b>19.39</b>     | <b>(TUNGSTEN)</b> |
| H         | <b>(0.094)</b>                | <b>(1.5)</b>                  | <b>(162)</b>                  | <b>(2.596)</b>   | MARBLE            |

### ANSWERS TO QUESTIONS IN EXERCISE 2-1

1. D.      2. C.      3. A.      4. A.

### COMPLETED CHART FROM EXERCISE 2-2

(Bolded values in parentheses represent the items that were to be filled in by the student.)

| Line | P1                | V1                          | T1            | P2                | V2                           | T2             |
|------|-------------------|-----------------------------|---------------|-------------------|------------------------------|----------------|
| 1    | 50 psig           | 20 ft <sup>3</sup>          | 100°F         | <b>(25 psia)</b>  | 50 ft <sup>3</sup>           | 80°F           |
| 2    | 50 psia           | 2,000 ft <sup>3</sup>       | 75°F          | 50 psia           | <b>(2291 ft<sup>3</sup>)</b> | 130°F          |
| 3    | 40 psia           | 30 in <sup>3</sup>          | 80°F          | 50 psia           | <b>(24 ft<sup>3</sup>)</b>   | 80°F           |
| 4    | <b>(100 psia)</b> | 20 ft <sup>3</sup>          | 500R          | 200 psia          | 12 ft <sup>3</sup>           | 600R           |
| 5    | 100 psia          | 10 ft <sup>3</sup>          | 600R          | 100 psia          | 25 ft <sup>3</sup>           | <b>(1500R)</b> |
| 6    | 80 psia           | <b>(150 ft<sup>3</sup>)</b> | 400R          | 150 psia          | 100 ft <sup>3</sup>          | 500R           |
| 7    | 150 psia          | 100 ft <sup>3</sup>         | <b>(700R)</b> | 300 psia          | 50 ft <sup>3</sup>           | 700R           |
| 8    | 80 psia           | 500 ft <sup>3</sup>         | 600R          | <b>(160 psia)</b> | 100 ft <sup>3</sup>          | 240R           |

accessible website, in whole or in part.

## ANSWERS TO QUESTIONS IN EXERCISE 2-2

1. D.
2. B.
3. Absolute pressure and temperature scales both have zero as their lowest values, so any pressure above 0 psia or temperature above zero degrees Rankin will be indicated by positive values. By keeping all of the values positive, the gas law as shown in Section 2.6 of the textbook will be a linear relationship existing

among the pressure, temperature, and volume of the gas. If non-absolute scales are used, the relationships become non-linear and significant calculation errors can, and will, arise.

## COMPLETED CHART FROM EXERCISE 2-3

(Bolded values in parentheses represent the items that were to be filled in by the student.)

| Line | Distance<br>(ft) | Weight<br>(lb) | Work<br>(ft-lb)    | Time<br>(min) | Power<br>(W)    | Power<br>(kW)  | Heat<br>(btuh)   | HP            |
|------|------------------|----------------|--------------------|---------------|-----------------|----------------|------------------|---------------|
| 1    | 500              | 100            | <b>(50,000)</b>    | 5             | <b>(226)</b>    | <b>(0.226)</b> | <b>(771)</b>     | 0.303         |
| 2    | <b>(20)</b>      | 500            | 10,000             | 2             | 113.03          | <b>(0.113)</b> | <b>(386)</b>     | <b>(0.15)</b> |
| 3    | <b>(4,409)</b>   | 250            | <b>(1,102,200)</b> | 1             | <b>(24,905)</b> | <b>(24.91)</b> | 85,000           | <b>(33.4)</b> |
| 4    | 1000             | <b>(1,106)</b> | <b>(1,105,500)</b> | 2             | <b>(25,000)</b> | 25             | <b>(85,325)</b>  | <b>(33.5)</b> |
| 5    | <b>(1000)</b>    | 150            | 150,000            | <b>(0.06)</b> | <b>(55,950)</b> | <b>(55.95)</b> | <b>(190,957)</b> | 75            |
| 6    | 10,000           | <b>(22.12)</b> | <b>(221,180)</b>   | 10            | <b>(5,000)</b>  | 5              | <b>(17,065)</b>  | <b>(6.7)</b>  |
| 7    | <b>(518.4)</b>   | 500            | <b>(259,220)</b>   | 1             | <b>(5,860)</b>  | <b>(5.86)</b>  | 20,000           | <b>(7.86)</b> |
| 8    | 5,000            | <b>(518.4)</b> | <b>(2,592,200)</b> | 5             | <b>(58,600)</b> | <b>(58.6)</b>  | 200,000          | <b>(78.6)</b> |

## ANSWERS TO QUESTIONS IN EXERCISE 2-3

1. B.
2. D.
3. B.