Unit 2

Matter and Energy

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

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 = 1 ÷ 1210 lb/ft^3 = 0.000826 ft^3/lb.
12. Density = 1 ÷ (0.001865 ft^3/lb) = 536.19 lb/ft^3.
13. Specific gravity = 171 lb/ft^3 ÷ 62.4 lb/ft^3 = 2.74.
14. Density is (4 lb ÷ 10 ft^3) = 0.4 lb/ft^3.
    Specific gravity is (0.4 lb/ft^3 ÷ 62.4 lb/ft^3) = 0.0064.
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 × distance.
23. 4 ft × 300 lb = 1200 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 = 1 horsepower.
26. (4 kW × 3413 Btu/kW) = 13,652 Btu/h.
27. 12,000 watts × 3.413 Btu/Wh = 40,956 Btu/h.
28. Kilowatt hour.

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

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

$$V_2 = \frac{(3000\,\text{ft}^3)(55+460)°\text{R}}{(75+460)°\text{R}} = 2887.8\,\text{ft}^3$$

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

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

$$P_2 = \frac{(10\,\text{psig} + 14.696)\ (10.5\ \text{in}^3)(180° + 460)°\text{R}}{(65+460)°\text{R}(1.5\ \text{in}^3)}$$

P_2 = 210.74 psia
P_2 = (210.74 psia − 14.696) = 196 psig

UNIT 2 ANSWERS TO REVIEW TEST QUESTIONS (LAB MANUAL)

1. C.
2. A.
3. B.
4. C.
5. D.
6. A.
7. D.
8. C.
9. C.
10. D.
11. D.
12. D.
13. 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^3)	Density (oz/in^3)	Density (lb/ft^3)	Specific Gravity	Substance
A	(**0.7**)	(**11.2**)	1208	(**19.36**)	(**GOLD**)
B	(**0.036**)	(**0.58**)	(**62.4**)	1	(**WATER**)
C	(**0.317**)	(**5.07**)	(**548**)	(**8.78**)	RED BRASS
D	0.3218	(**5.15**)	(**556**)	(**8.91**)	(**COPPER**)
E	(**0.033**)	0.5324	(**57.5**)	(**0.92**)	(**ICE**)
F	(**0.099**)	(**1.58**)	171	(**2.74**)	(**ALUMINUM**)
G	(**0.70**)	(**11.2**)	(**1210**)	**19.39**	(**TUNGSTEN**)
H	(**0.094**)	(**1.5**)	(**162**)	(**2.596**)	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^3	100°F	(**25 psia**)	50 ft^3	80°F
2	50 psia	2,000 ft^3	75°F	50 psia	(**2291 ft^3**)	130°F
3	40 psia	30 in^3	80°F	50 psia	(**24 ft^3**)	80°F
4	(**100 psia**)	20 ft^3	500 R	200 psia	12 ft^3	600 R
5	100 psia	10 ft^3	600 R	100 psia	25 ft^3	(**1500 R**)
6	80 psia	(**150 ft^3**)	400 R	150 psia	100 ft^3	500 R
7	150 psia	100 ft^3	(**700 R**)	300 psia	50 ft^3	700 R
8	80 psia	500 ft^3	600 R	(**160 psia**)	100 ft^3	240 R

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

ANSWERS TO QUESTIONS IN EXERCISE 2-3

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