PRACTICE EXAM 8: PHYSICAL SETTING/CHEMISTRY SIMULATION (85 QUESTIONS)

1. A gas occupies 2.0 L at 100. kPa and 200. K. What volume will it occupy at 200. kPa and 400. K?

A. 2.0 L

B. 4.0 L

C. 1.0 L

D. 8.0 L

2. In the reaction 2 H_2 + O_2 → 2 H_2O, what mass of water is produced from 32 g of O_2? (GFM: O_2 = 32, H_2O = 18)

A. 18 g

B. 32 g

C. 36 g

D. 64 g

3. How much heat is required to raise the temperature of 200. g of water from 20.0 °C to 50.0 °C? (specific heat = 4.18 J/g·K)

A. 6,270 J

B. 836 J

C. 12,540 J

D. 25,080 J

4. What is the molarity of a solution made by dissolving 80. g of NaOH in enough water to make 2.0 L of solution? (GFM NaOH = 40)

A. 0.50 M

B. 1.0 M

C. 2.0 M

D. 4.0 M

5. How many moles of gas are present in 67.2 L of a gas at STP? (molar volume = 22.4 L/mol)

A. 67.2 mol

B. 22.4 mol

C. 1.0 mol

D. 3.0 mol

6. A radioisotope has a half-life of 4.0 days. What fraction of the original sample remains after 16 days?

A. 1/16

B. 1/4

C. 1/8

D. 1/2

7. What is the percent by mass of oxygen in calcium carbonate, $CaCO_3$? (Ca = 40, C = 12, O = 16)

A. 16%

B. 12%

C. 40%

D. 48%

8. A gas at 300. kPa occupies 4.0 L. At constant temperature, if the volume changes to 6.0 L, the new pressure is

A. 450 kPa

B. 300 kPa

C. 200 kPa

D. 100 kPa

9. How many moles are in 49 g of H_2SO_4? (GFM = 98)

A. 0.50 mol

B. 1.0 mol

C. 2.0 mol

D. 49 mol

10. In the reaction $N_2 + 3 H_2 \rightarrow 2 NH_3$, what mass of NH_3 is produced from 28 g of N_2? (GFM: N_2 = 28, NH_3 = 17)

A. 17 g

B. 34 g

C. 28 g

D. 51 g

11. A gas occupies 3.0 L at 300. K. At constant pressure, at what temperature will it occupy 6.0 L?

A. 150 K

B. 600 K

C. 300 K

D. 900 K

12. What is the percent by mass of hydrogen in methane, CH_4? (C = 12, H = 1)

A. 12%

B. 4%

C. 50%

D. 25%

13. A 100. g metal sample absorbs 900. J of heat and its temperature rises by 30.0 K. What is the specific heat of the metal?

A. 9.0 J/g·K

B. 3.0 J/g·K

C. 0.90 J/g·K

D. 0.30 J/g·K

14. How many moles of solute are in 0.50 L of a 3.0 M solution?

A. 1.5 mol

B. 6.0 mol

C. 0.17 mol

D. 3.0 mol

15. A gas occupies 2.0 L at 100. kPa and 300. K. If the pressure becomes 150. kPa and the volume stays 2.0 L, the new temperature is

A. 200 K

B. 300 K

C. 450 K

D. 600 K

16. What is the gram-formula mass of glucose, $C_6H_{12}O_6$? (C = 12, H = 1, O = 16)

A. 29 g/mol

B. 96 g/mol

C. 150 g/mol

D. 180 g/mol

17. A 120. g sample of a radioisotope has a half-life of 6.0 years. What mass remains after 18 years?

A. 60 g

B. 30 g

C. 40 g

D. 15 g

18. In the reaction $2\ KClO_3 \rightarrow 2\ KCl + 3\ O_2$, how many moles of O_2 are produced from 4.0 moles of $KClO_3$?

A. 4.0 mol

B. 6.0 mol

C. 2.0 mol

D. 3.0 mol

19. In a titration, 25.0 mL of 0.20 M NaOH neutralizes 20.0 mL of HCl in a one-to-one reaction. The molarity of the HCl is

A. 0.20 M

B. 0.25 M

C. 0.16 M

D. 0.40 M

20. A sample of a metal has a mass of 47.0 g and a volume of 5.0 cm^3. What is its density?

A. 235 g/cm^3

B. 0.11 g/cm^3

C. 9.4 g/cm^3

D. 52 g/cm^3

21. A gas occupies 5.0 L at 400. K and 200. kPa. At 200. K and 100. kPa, the new volume is

A. 2.5 L

B. 5.0 L

C. 10. L

D. 20. L

22. How many molecules are in 2.0 moles of CO_2? (Avogadro's number = 6.02×10^{23})

A. 6.02×10^{23}

B. 3.01×10^{23}

C. 6.02×10^{24}

D. 1.2×10^{24}

23. A student measures a density as 8.4 g/cm^3; the accepted value is 8.0 g/cm^3. The percent error is

A. 0.4%

B. 8.0%

C. 4.0%

D. 5.0%

24. In the reaction $C + O_2 \rightarrow CO_2$, what mass of CO_2 is produced from 6.0 g of carbon? (C = 12, CO_2 = 44)

A. 6.0 g

B. 12 g

C. 22 g

D. 44 g

25. If 100. mL of a 2.0 M solution is diluted with water to a total volume of 400. mL, the new concentration is

A. 8.0 M

B. 2.0 M

C. 0.50 M

D. 1.0 M

26. How much heat is needed to melt 50.0 g of ice at 0 °C? (heat of fusion of water = 334 J/g)

A. 334 J

B. 4,180 J

C. 113,000 J

D. 16,700 J

27. How many moles are in 11.2 L of a gas at STP?

A. 0.50 mol

B. 1.0 mol

C. 11.2 mol

D. 22.4 mol

28. An element has isotopes of mass 6.0 amu (25% abundance) and 7.0 amu (75% abundance). Its average atomic mass is

A. 6.0 amu

B. 6.75 amu

C. 7.0 amu

D. 6.5 amu

29. A gas at 250. K and 100. kPa occupies 4.0 L. At 500. K, if the volume stays 4.0 L, the new pressure is

A. 50 kPa

B. 100 kPa

C. 200 kPa

D. 400 kPa

30. A compound is 75% carbon and 25% hydrogen by mass. Using C = 12 and H = 1, its empirical formula is

A. CH_4

B. C_4H

C. CH

D. C_2H_8

31. What mass of water can be raised 10.0 K by 8,360 J of heat? (specific heat = 4.18 J/g·K)

A. 100. g

B. 200. g

C. 50. g

D. 836 g

32. What is the gram-formula mass of $(NH_4)_2SO_4$? (N = 14, H = 1, S = 32, O = 16)

A. 132 g/mol

B. 114 g/mol

C. 96 g/mol

D. 66 g/mol

33. In the reaction $4\ NH_3 + 5\ O_2 \rightarrow 4\ NO + 6\ H_2O$, how many moles of O_2 react with 8.0 moles of NH_3?

A. 10. mol

B. 8.0 mol

C. 5.0 mol

D. 6.0 mol

34. A solution contains 0.010 g of solute in 1,000 g of solution. The concentration in parts per million is (ppm = grams solute ÷ grams solution × 1,000,000)

A. 1 ppm

B. 100 ppm

C. 10 ppm

D. 1,000 ppm

35. A gas occupies 6.0 L at 300. K and 100. kPa. At 600. K and 300. kPa, the new volume is

A. 6.0 L

B. 4.0 L

C. 12 L

D. 2.0 L

36. How many moles are present in 100. g of $CaCO_3$? (GFM = 100)

A. 0.10 mol

B. 10. mol

C. 1.0 mol

D. 100 mol

37. A 250. g sample of water absorbs 5,225 J of heat. What is its temperature change? (C = 4.18 J/g·K)

A. 5.0 K

B. 10. K

C. 2.5 K

D. 20. K

38. A 44 g sample of CO_2 at STP occupies what volume? (GFM CO_2 = 44, molar volume = 22.4 L)

A. 22.4 L

B. 44.8 L

C. 11.2 L

D. 1.0 L

39. In the reaction $2\ Mg + O_2 \rightarrow 2\ MgO$, what mass of MgO is produced from 48 g of Mg? (Mg = 24, MgO = 40)

A. 24 g

B. 40 g

C. 80 g

D. 48 g

40. A radioisotope decays from 80. g to 10. g. If its half-life is 5.0 days, how much time has elapsed?

A. 5.0 days

B. 10. days

C. 15 days

D. 20. days

41. How many liters of a 0.50 M solution contain 2.0 moles of solute?

A. 1.0 L

B. 0.25 L

C. 2.5 L

D. 4.0 L

42. What is the percent by mass of nitrogen in NH_4NO_3? (N = 14, H = 1, O = 16)

A. 14%

B. 17.5%

C. 28%

D. 35%

43. A gas at 400. kPa occupies 1.0 L. At constant temperature and 100. kPa, the volume is

A. 4.0 L

B. 0.25 L

C. 2.0 L

D. 40. L

44. How much heat is required to vaporize 10.0 g of water at its boiling point? (heat of vaporization = 2,260 J/g)

A. 226 J

B. 334 J

C. 4,180 J

D. 22,600 J

45. How many moles of chloride ions are in 2.0 moles of $AlCl_3$?

A. 2.0 mol

B. 3.0 mol

C. 5.0 mol

D. 6.0 mol

46. An element has isotopes of mass 20. amu (90.% abundance) and 22 amu (10.% abundance). Its average atomic mass is

A. 20.2 amu

B. 21 amu

C. 22 amu

D. 20 amu

47. A gas occupies 4.0 L at 200. K and 100. kPa. At 100. kPa, if the volume becomes 8.0 L, the temperature is

A. 200 K

B. 400 K

C. 100 K

D. 800 K

48. How many moles are in 200. g of $CaCO_3$? (GFM = 100)

A. 0.50 mol

B. 100 mol

C. 1.0 mol

D. 2.0 mol

49. How much heat is needed to warm 500. g of water by 20.0 K? (C = 4.18 J/g·K)

A. 4,180 J

B. 836 J

C. 41,800 J

D. 10,000 J

50. A reaction has a theoretical yield of 50. g but produces only 40. g. The percent yield is (actual ÷ theoretical × 100)

A. 50%

B. 80%

C. 90%

D. 125%

51. In the reaction $2 H_2 + O_2 \rightarrow 2 H_2O$, how many grams of O_2 are needed to react with 4.0 moles of H_2? (O_2 = 32)

A. 32 g

B. 128 g

C. 64 g

D. 16 g

52. What is the molarity of a solution containing 0.25 mole of solute in 500. mL of solution?

A. 0.125 M

B. 0.25 M

C. 1.25 M

D. 0.50 M

53. A gas occupies 2.0 L at 300. K and 150. kPa. At 4.0 L and 600. K, the new pressure is

A. 37.5 kPa

B. 600 kPa

C. 150 kPa

D. 300 kPa

54. How many moles are represented by 3.01×10^{23} atoms?

A. 1.0 mol

B. 0.50 mol

C. 2.0 mol

D. 6.02 mol

55. A sample of ice absorbs 6,680 J to melt completely at 0 °C. What mass of ice melted? (heat of fusion = 334 J/g)

A. 10. g

B. 50. g

C. 20. g

D. 100 g

56. The molecular formula C_6H_6 has the empirical formula

A. C_6H_6

B. C_2H_2

C. C_3H_3

D. CH

57. A gas occupies 8.0 L at 50. kPa. At constant temperature, to compress it to 2.0 L the pressure must be

A. 200 kPa

B. 50 kPa

C. 12.5 kPa

D. 100 kPa

58. What is the gram-formula mass of $Ca_3(PO_4)_2$? (Ca = 40, P = 31, O = 16)

A. 87 g/mol

B. 215 g/mol

C. 310 g/mol

D. 278 g/mol

59. How many grams of NaCl are needed to make 0.50 L of a 2.0 M solution? (GFM NaCl = 58.5)

A. 29.25 g

B. 58.5 g

C. 117 g

D. 234 g

60. A 50.0 g iron sample absorbs 1,125 J of heat, raising its temperature by 50.0 K. The specific heat of iron is

A. 0.90 J/g·K

B. 0.45 J/g·K

C. 1.13 J/g·K

D. 2.25 J/g·K

61. In the reaction $CH_4 + 2\ O_2 \rightarrow CO_2 + 2\ H_2O$, how many moles of O_2 are needed to burn 3.0 moles of CH_4?

A. 3.0 mol

B. 2.0 mol

C. 6.0 mol

D. 1.5 mol

62. A 64 g sample of a radioisotope with a half-life of 3.0 hours decays for 12 hours. What mass remains?

A. 4.0 g

B. 8.0 g

C. 16 g

D. 2.0 g

63. What is the percent by mass of oxygen in water, H_2O? (H = 1, O = 16)

A. 11%

B. 89%

C. 50%

D. 33%

64. What volume does 2.5 moles of a gas occupy at STP? (22.4 L/mol)

A. 56 L

B. 22.4 L

C. 11.2 L

D. 2.5 L

65. To dilute 200. mL of a 6.0 M solution to 2.0 M, what total volume is needed? ($M_1V_1 = M_2V_2$)

A. 100 mL

B. 200 mL

C. 400 mL

D. 600 mL

66. How many moles are in 36 g of carbon? (atomic mass C = 12)

A. 12 mol

B. 3.0 mol

C. 0.33 mol

D. 36 mol

67. In $2\ H_2 + O_2 \rightarrow 2\ H_2O$, what mass of water forms from 2.0 g of H_2? (H_2 = 2, H_2O = 18)

A. 9.0 g

B. 2.0 g

C. 36 g

D. 18 g

68. A gas occupies 10. L at 500. K and 200. kPa. At 250. K and 100. kPa, the new volume is

A. 10. L

B. 5.0 L

C. 20. L

D. 2.5 L

69. How many moles of solute are in 250. mL of a 0.80 M solution?

A. 0.10 mol

B. 0.20 mol

C. 0.40 mol

D. 0.80 mol

70. How much heat is absorbed by 100. g of copper when its temperature rises 40.0 K? (specific heat of copper = 0.385 J/g·K)

A. 38.5 J

B. 100 J

C. 385 J

D. 1,540 J

71. A compound is 40.% sulfur and 60.% oxygen by mass. Using S = 32 and O = 16, the empirical formula is

A. SO

B. S_3O

C. SO_2

D. SO_3

72. What is the molarity of a solution made by dissolving 117 g of NaCl in enough water to make 2.0 L? (GFM = 58.5)

A. 0.50 M

B. 2.0 M

C. 1.0 M

D. 4.0 M

73. A gas occupies 2.0 L at 100. K. At constant pressure and 300. K, the volume is

A. 6.0 L

B. 2.0 L

C. 0.67 L

D. 4.0 L

74. What is the mass of 0.25 mole of $CaCO_3$? (GFM = 100)

A. 100 g

B. 25 g

C. 50 g

D. 4.0 g

75. A measured value is 18.0 and the accepted value is 20.0. The percent error is

A. 2.0%

B. 10.%

C. 18%

D. 90%

76. After 5 half-lives, the fraction of a radioactive sample remaining is

A. 1/32

B. 1/5

C. 1/10

D. 1/16

77. A gas occupies 3.0 L at 200. kPa. At constant temperature and 1.0 L, the pressure is

A. 67 kPa

B. 200 kPa

C. 600 kPa

D. 100 kPa

78. What is the gram-formula mass of $Al_2(SO_4)_3$? (Al = 27, S = 32, O = 16)

A. 150 g/mol

B. 278 g/mol

C. 342 g/mol

D. 123 g/mol

79. What volume of a 4.0 M solution contains 1.0 mole of solute?

A. 4.0 L

B. 0.25 L

C. 1.0 L

D. 0.50 L

80. How much heat does 1,000. g of water release when it cools from 80.0 °C to 30.0 °C? (C = 4.18 J/g·K)

A. 209,000 J

B. 41,800 J

C. 4,180 J

D. 2,090 J

81. How many moles are in 44.8 L of gas at STP?

A. 1.0 mol

B. 2.0 mol

C. 44.8 mol

D. 22.4 mol

82. In the reaction 2 Na + Cl_2 → 2 NaCl, what mass of NaCl forms from 46 g of Na? (Na = 23, NaCl = 58.5)

A. 58.5 g

B. 117 g

C. 46 g

D. 23 g

83. A gas occupies 4.0 L at 300. K and 100. kPa. At 2.0 L and 600. K, the new pressure is

A. 100 kPa

B. 200 kPa

C. 400 kPa

D. 50 kPa

84. What is the percent by mass of calcium in calcium oxide, CaO? (Ca = 40, O = 16)

A. 71%

B. 29%

C. 40%

D. 50%

85. A solution contains 4.0 moles of solute in 8.0 L of solution. Its molarity is

A. 0.50 M

B. 2.0 M

C. 32 M

D. 4.0 M

Practice Exam 8 – Explained Answer Key

1. A — Applying the combined gas law, $P_1V_1/T_1 = P_2V_2/T_2$, gives (100 × 2.0)/200 = (200 × V_2)/400. Solving, 1.0 = 0.50 V_2, so V_2 = 2.0 L. Doubling both pressure and temperature leaves the volume unchanged.
2. C — A 32 g sample of O_2 equals 1.0 mole (32 ÷ 32). The 1:2 mole ratio of O_2 to H_2O gives 2.0 moles of water, which at 18 g/mol is 36 g. Mole ratios from the balanced equation drive the mass calculation.
3. D — Using $q = mC\Delta T$ with ΔT = 30.0 K gives q = 200 × 4.18 × 30.0 = 25,080 J. The heat absorbed is proportional to mass, specific heat, and temperature change. This is the standard calorimetry relationship.
4. B — Molarity is moles per liter, and 80. g of NaOH is 80 ÷ 40 = 2.0 moles. Dividing 2.0 moles by 2.0 L gives 1.0 M. Concentration depends on both the amount of solute and the solution volume.

5. D — At STP, dividing the volume by the molar volume gives moles: 67.2 ÷ 22.4 = 3.0 moles. One mole of any gas occupies 22.4 L at STP. This conversion links gas volume to amount.
6. A — In 16 days the sample passes through 16 ÷ 4.0 = 4 half-lives. Each half-life halves the amount, so the fraction remaining is $(1/2)^4 = 1/16$. Half-life governs exponential radioactive decay.
7. D — In $CaCO_3$ (formula mass 100), the three oxygen atoms total 48. Dividing 48 by 100 and multiplying by 100 gives 48%. Percent composition is each element's mass divided by the total formula mass.
8. C — At constant temperature, Boyle's law gives $P_1V_1 = P_2V_2$, so $300 \times 4.0 = P_2 \times 6.0$. Solving, $P_2 = 1200 \div 6.0 = 200$ kPa. Increasing volume lowers pressure proportionally.
9. A — Moles equal mass divided by gram-formula mass: 49 ÷ 98 = 0.50 mole. The GFM converts a measured mass into an amount in moles. This is the central mole conversion.
10. B — A 28 g sample of N_2 is 1.0 mole (28 ÷ 28). The 1:2 ratio of N_2 to NH_3 yields 2.0 moles of NH_3, which at 17 g/mol is 34 g. The balanced equation sets the product amount.
11. B — At constant pressure, Charles's law gives $V_1/T_1 = V_2/T_2$, so $3.0/300 = 6.0/T_2$. Solving, $T_2 = 600$ K. Doubling the volume requires doubling the kelvin temperature.
12. D — In CH_4 (formula mass 16), the four hydrogen atoms total 4. Dividing 4 by 16 gives 25%. Percent composition compares the element's mass to the whole.
13. D — Specific heat is $q \div (m\Delta T) = 900 \div (100 \times 30.0) = 900 \div 3000 = 0.30$ J/g·K. Rearranging the calorimetry equation isolates the specific heat. This value is characteristic of the material.
14. A — Moles of solute equal molarity times volume: 3.0 × 0.50 = 1.5 moles. Multiplying concentration by volume gives the amount present. This is the inverse of the molarity definition.
15. C — The combined gas law gives $(100 \times 2.0)/300 = (150 \times 2.0)/T_2$, so $0.667 = 300/T_2$. Solving, $T_2 = 450$ K. With volume fixed, raising pressure requires a proportional rise in temperature.
16. D — Glucose, $C_6H_{12}O_6$, sums to 6(12) + 12(1) + 6(16) = 72 + 12 + 96 = 180 g/mol. Each element's atoms are multiplied by its atomic mass and totaled. This gives the gram-formula mass.
17. D — In 18 years the sample passes through 18 ÷ 6.0 = 3 half-lives. Halving 120. g three times gives 120 → 60 → 30 → 15 g. Each half-life reduces the mass by half.
18. B — The 2:3 mole ratio of $KClO_3$ to O_2 gives 4.0 × (3/2) = 6.0 moles of O_2. Coefficients from the balanced equation set the ratio. This converts moles of reactant to moles of product.
19. B — Neutralization gives M_aV_a = M_b V_b, so $M_a \times 20.0 = 0.20 \times 25.0$. Solving, $M_a = 5.0 \div 20.0 = 0.25$ M. The 1:1 ratio lets the volumes and one concentration find the other.
20. C — Density is mass divided by volume: 47.0 ÷ 5.0 = 9.4 g/cm^3. Dividing mass by the space it occupies gives density. This intensive property identifies the substance.
21. B — The combined gas law gives $(200 \times 5.0)/400 = (100 \times V_2)/200$, so $2.5 = 0.50 V_2$. Solving, $V_2 = 5.0$ L. Halving both pressure and temperature leaves the volume unchanged.
22. D — Multiplying moles by Avogadro's number gives $2.0 \times 6.02 \times 10^{23} = 1.2 \times 10^{24}$ molecules. One mole contains 6.02×10^{23} particles. This converts amount to a particle count.
23. D — Percent error is the absolute difference over the accepted value, times 100: (0.4 ÷ 8.0) × 100 = 5.0%. The deviation is compared to the true value. A small percent error reflects good accuracy.
24. C — A 6.0 g sample of carbon is 6.0 ÷ 12 = 0.50 mole. The 1:1 ratio gives 0.50 mole of CO_2, which at 44 g/mol is 22 g. The mole ratio connects the masses of reactant and product.
25. C — Dilution follows $M_1V_1 = M_2V_2$, so $2.0 \times 100 = M_2 \times 400$. Solving, $M_2 = 200 \div 400 = 0.50$ M. Adding water increases volume and lowers concentration proportionally.
26. D — Melting uses q = mH_f = 50.0 × 334 = 16,700 J. The heat of fusion is the energy needed to melt one gram. Multiplying by mass gives the total heat for the phase change.

27. A — At STP, 11.2 ÷ 22.4 = 0.50 mole. The molar volume of 22.4 L converts gas volume to moles. Half the molar volume corresponds to half a mole.
28. B — The weighted average is 6.0(0.25) + 7.0(0.75) = 1.5 + 5.25 = 6.75 amu. Each isotope's mass is weighted by its abundance. This gives the element's average atomic mass.
29. C — At constant volume, $P_1/T_1 = P_2/T_2$, so $100/250 = P_2/500$. Solving, P_2 = 200 kPa. Doubling the kelvin temperature doubles the pressure.
30. A — Dividing by atomic masses gives 75 ÷ 12 = 6.25 for carbon and 25 ÷ 1 = 25 for hydrogen, a 1:4 ratio. This yields the empirical formula CH_4. Percent composition is converted to a mole ratio.
31. B — Rearranging q = mCΔT gives m = q ÷ (CΔT) = 8,360 ÷ (4.18 × 10.0) = 8,360 ÷ 41.8 = 200. g. The mass is found from the heat, specific heat, and temperature change. This inverts the calorimetry equation.
32. A — Ammonium sulfate, $(NH_4)_2SO_4$, sums to 2(14 + 4) + 32 + 4(16) = 36 + 32 + 64 = 132 g/mol. The parentheses subscript doubles the ammonium group. Each part is totaled for the gram-formula mass.
33. A — The 4:5 mole ratio of NH_3 to O_2 gives 8.0 × (5/4) = 10. moles of O_2. The balanced coefficients set the ratio. This converts moles of one reactant to another.
34. C — Parts per million is (0.010 ÷ 1,000) × 1,000,000 = 10 ppm. The mass fraction of solute is scaled by one million. This unit expresses very dilute concentrations.
35. B — The combined gas law gives $(100 \times 6.0)/300 = (300 \times V_2)/600$, so $2.0 = 0.50\ V_2$. Solving, V_2 = 4.0 L. The pressure tripling outweighs the temperature doubling, reducing the volume.
36. C — Moles equal mass over gram-formula mass: 100. ÷ 100 = 1.0 mole. The GFM of $CaCO_3$ is 100. Dividing the sample mass by it gives the amount.
37. A — Rearranging q = mCΔT gives ΔT = q ÷ (mC) = 5,225 ÷ (250 × 4.18) = 5,225 ÷ 1045 = 5.0 K. The temperature change follows from the heat absorbed and the mass. This isolates ΔT.
38. A — A 44 g sample of CO_2 is 1.0 mole (44 ÷ 44), which at STP occupies 22.4 L. The molar volume applies to one mole of any gas. The mass first converts to moles, then to volume.
39. C — A 48 g sample of Mg is 48 ÷ 24 = 2.0 moles. The 2:2 ratio gives 2.0 moles of MgO, which at 40 g/mol is 80 g. The mole ratio links the masses.
40. C — Halving 80. g to reach 10. g takes three steps (80 → 40 → 20 → 10), so three half-lives. At 5.0 days each, the elapsed time is 15 days. The number of halvings sets the total time.
41. D — Volume equals moles divided by molarity: 2.0 ÷ 0.50 = 4.0 L. Rearranging the molarity definition isolates volume. This finds the volume holding a given amount of solute.
42. D — In NH_4NO_3 (formula mass 80), the two nitrogen atoms total 28. Dividing 28 by 80 gives 35%. Both nitrogen atoms are counted for percent composition.
43. A — Boyle's law gives $400 \times 1.0 = 100 \times V_2$, so V_2 = 4.0 L. Lowering the pressure to one-fourth expands the volume fourfold. Pressure and volume are inversely related.
44. D — Vaporization uses q = mH_v = 10.0 × 2,260 = 22,600 J. The heat of vaporization is the energy to boil one gram. Multiplying by mass gives the total heat for the phase change.
45. D — Each $AlCl_3$ unit contains three chloride ions, so 2.0 moles yields 2.0 × 3 = 6.0 moles of Cl^-. The subscript sets the ion ratio. This counts ions within a compound.
46. A — The weighted average is 20.(0.90) + 22(0.10) = 18.0 + 2.2 = 20.2 amu. Each isotope is weighted by its abundance. The result lies closer to the more abundant isotope.
47. B — At constant pressure, $V_1/T_1 = V_2/T_2$, so $4.0/200 = 8.0/T_2$. Solving, T_2 = 400 K. Doubling the volume requires doubling the kelvin temperature.
48. D — Moles equal mass over gram-formula mass: 200. ÷ 100 = 2.0 moles. The GFM of $CaCO_3$ is 100. Dividing the larger mass gives two moles.

49. C — Using $q = mC\Delta T$ gives 500 × 4.18 × 20.0 = 41,800 J. The heat scales with mass and temperature change. This is the calorimetry calculation for warming water.
50. B — Percent yield is actual over theoretical, times 100: (40. ÷ 50.) × 100 = 80%. The obtained product is compared to the maximum possible. This measures reaction efficiency.
51. C — The 2:1 ratio of H_2 to O_2 gives 4.0 ÷ 2 = 2.0 moles of O_2, which at 32 g/mol is 64 g. The mole ratio converts moles of one reactant to the mass of another. The balanced equation sets the ratio.
52. D — Molarity is moles per liter, and 500. mL is 0.500 L, so 0.25 ÷ 0.500 = 0.50 M. The volume must be in liters. Dividing moles by liters gives concentration.
53. C — The combined gas law gives (150 × 2.0)/300 = (P_2 × 4.0)/600, so 1.0 = 4.0 P_2/600. Solving, P_2 = 600 ÷ 4.0 = 150 kPa. The doubled volume and doubled temperature offset, leaving pressure unchanged.
54. B — Dividing particles by Avogadro's number gives $3.01 \times 10^{23} \div 6.02 \times 10^{23} = 0.50$ mole. The constant converts a particle count to moles. Half of Avogadro's number is half a mole.
55. C — Rearranging q = mH_f gives m = q ÷ H_f = 6,680 ÷ 334 = 20. g. The heat of fusion relates energy to mass melted. Dividing the heat by it gives the mass.
56. D — Dividing the subscripts of C_6H_6 by six gives the empirical formula CH. The empirical formula is the simplest whole-number ratio. It reduces the molecular formula to lowest terms.
57. A — Boyle's law gives 50. × 8.0 = P_2 × 2.0, so P_2 = 400 ÷ 2.0 = 200 kPa. Compressing to one-fourth the volume quadruples the pressure. Pressure and volume vary inversely.
58. C — Calcium phosphate, $Ca_3(PO_4)_2$, sums to 3(40) + 2(31 + 64) = 120 + 190 = 310 g/mol. The parentheses subscript doubles the phosphate group. Each part is totaled for the formula mass.
59. B — Moles needed equal 2.0 × 0.50 = 1.0 mole, which at 58.5 g/mol is 58.5 g. Molarity times volume gives moles, then mass. This finds the solute mass for a target solution.
60. B — Specific heat is $q \div (m\Delta T)$ = 1,125 ÷ (50.0 × 50.0) = 1,125 ÷ 2500 = 0.45 J/g·K. Rearranging the calorimetry equation isolates specific heat. This value characterizes iron.
61. C — The 1:2 ratio of CH_4 to O_2 gives 3.0 × 2 = 6.0 moles of O_2. The balanced equation sets the ratio. Combustion requires twice the moles of oxygen as methane.
62. A — In 12 hours the sample passes through 12 ÷ 3.0 = 4 half-lives. Halving 64 g four times gives 64 → 32 → 16 → 8 → 4 g. Each half-life reduces the mass by half.
63. B — In H_2O (formula mass 18), oxygen contributes 16. Dividing 16 by 18 gives about 89%. Oxygen dominates the mass of water. Percent composition compares the element to the whole.
64. A — Multiplying moles by molar volume gives 2.5 × 22.4 = 56 L. At STP each mole occupies 22.4 L. This converts an amount of gas to its volume.
65. D — Dilution follows $M_1V_1 = M_2V_2$, so 6.0 × 200 = 2.0 × V_2. Solving, V_2 = 1,200 ÷ 2.0 = 600 mL. Lowering the concentration threefold requires tripling the volume.
66. B — Moles equal mass over atomic mass: 36 ÷ 12 = 3.0 moles. The atomic mass of carbon converts grams to moles. Dividing the mass gives the amount.
67. D — A 2.0 g sample of H_2 is 1.0 mole (2.0 ÷ 2). The 2:2 ratio gives 1.0 mole of water, which at 18 g/mol is 18 g. The balanced equation links the masses.
68. A — The combined gas law gives (200 × 10)/500 = (100 × V_2)/250, so 4.0 = 0.40 V_2. Solving, V_2 = 10. L. Halving both pressure and temperature leaves the volume unchanged.
69. B — Moles equal molarity times volume: 0.80 × 0.250 = 0.20 mole. The volume is converted to liters first. Multiplying gives the amount of solute.
70. D — Using $q = mC\Delta T$ gives 100 × 0.385 × 40.0 = 1,540 J. The heat scales with mass, specific heat, and temperature change. Copper's low specific heat means modest heat for a large rise.

71. D — Dividing by atomic masses gives 40 ÷ 32 = 1.25 for sulfur and 60 ÷ 16 = 3.75 for oxygen, a 1:3 ratio. This yields the empirical formula SO_3. Percent composition becomes a mole ratio.
72. C — Moles equal 117 ÷ 58.5 = 2.0, and dividing by 2.0 L gives 1.0 M. The mass first converts to moles using the GFM. Molarity is then moles per liter.
73. A — Charles's law gives $2.0/100 = V_2/300$, so $V_2 = 6.0$ L. Tripling the kelvin temperature triples the volume at constant pressure. Volume and temperature are directly proportional.
74. B — Mass equals moles times gram-formula mass: 0.25 × 100 = 25 g. The GFM of $CaCO_3$ is 100. Multiplying by the number of moles gives the mass.
75. B — Percent error is the difference over the accepted value, times 100: (2.0 ÷ 20.0) × 100 = 10.%. The deviation is compared to the true value. This quantifies measurement accuracy.
76. A — After 5 half-lives the fraction remaining is $(1/2)^5 = 1/32$. Each half-life halves the amount. Five successive halvings leave one thirty-second.
77. C — Boyle's law gives $200 \times 3.0 = P_2 \times 1.0$, so $P_2 = 600$ kPa. Compressing to one-third the volume triples the pressure. Pressure and volume are inversely related.
78. C — Aluminum sulfate, $Al_2(SO_4)_3$, sums to 2(27) + 3(32 + 64) = 54 + 288 = 342 g/mol. The parentheses subscript triples the sulfate group. Each part is totaled for the formula mass.
79. B — Volume equals moles divided by molarity: 1.0 ÷ 4.0 = 0.25 L. Rearranging the molarity definition isolates volume. This finds the volume holding one mole.
80. A — Using $q = mC\Delta T$ with $\Delta T = 50.0$ K gives 1,000 × 4.18 × 50.0 = 209,000 J. The heat released scales with mass and temperature drop. Cooling releases the same energy that warming would absorb.
81. B — At STP, 44.8 ÷ 22.4 = 2.0 moles. The molar volume converts gas volume to moles. Twice the molar volume corresponds to two moles.
82. B — A 46 g sample of Na is 46 ÷ 23 = 2.0 moles. The 2:2 ratio gives 2.0 moles of NaCl, which at 58.5 g/mol is 117 g. The mole ratio links the masses.
83. C — The combined gas law gives $(100 \times 4.0)/300 = (P_2 \times 2.0)/600$, so $1.333 = 2.0\ P_2/600$. Solving, $P_2 = 800 \div 2.0 = 400$ kPa. Halving the volume and doubling the temperature both raise the pressure.
84. A — In CaO (formula mass 56), calcium contributes 40. Dividing 40 by 56 gives about 71%. Calcium makes up most of the mass of calcium oxide.
85. A — Molarity is moles per liter: 4.0 ÷ 8.0 = 0.50 M. Dividing the amount of solute by the solution volume gives concentration. This is the defining ratio of molarity.