Answer Key

Side Note: Before you go on, I would like to apologize for how messy the answer key is. I was trying to write down the calculations in such a way that you could type them into your calculator easily, and it was not my intention to make the answer key confusing in any way. Also, if you have any questions, thoughts, comments, feedback, or if there is something wrong with the key, please feel free to email me at azboy1910@gmail.com. I still make many mistakes, and I'm always looking to improve.

Section 1: Density, Buoyancy and Pressure

1. Density is the measure of how compact the particles of a substance are, how closely together they are, how large the forces of attraction between particles is. It is measured by mass per unit volume. [0.5 points, give half credit if just mass/volume] Some units of density are g/mL, kg/m^3, g/L, kg/L, etc. Types of density include area (surface) density, number density, volumetric mass density, population density, among others. [0.5 points]

2. Density and buoyancy are related to one another because of how they affect one another, in terms of a substance in a fluid. If the density of the substance is less than the density of the fluid and increases, the buoyant force on the substance will also increase. If the substance's density decreases, however, the buoyant force on the substance will also decrease. Density determines how much of a substance will float or sink, and therefore determines the magnitude of the buoyant force on it. Now, there is a point where density doesn't affect buoyancy anymore, which is when the substance's density is already greater than the density of the fluid, in which case the buoyant force will remain constant if the density of the substance is increased further. [0.5 points] These two factors affect our daily lives because without density and buoyancy, certain objects would not be able to float in certain fluids, such as the clouds, hot air balloons that people go on, a boat, etc. Also, without the density of us humans, if we just had zero density, we would be floating upwards and into space, where we couldn't live for too long due to the fact the gravity force of our mass pulls us down to Earth. [0.5 points]

3.
   a. $\rho N = \#/V$

      23 people ÷ ((80.0 m × 10^{-6}) (40.0 m × 10^{-6}) (50.0 m × 10^{-6})) = 1.4 × 10^{14} people/μm^3

   b. $\rho = m/V$

      (1.5 g × 50 marbles + 0.5 g) ÷ (100/1000 L) = 760 g/L

   c. $\rho N = \#/V$

      Factor Increase or Decrease = larger value/smaller value

      29 people ÷ ((80.0 m × 10^{-6}) (40.0 m × 10^{-6}) (50.0 m × 10^{-6})) ÷ (1.4 × 10^{14} people/μm^3) = Increased by a factor of 1.3.

4.
   a. $\rho = m/V$

$(350/1000 \text{ kg}) \div ((50. \text{ g} \div 2.32 \text{ g/mL} + 300. \text{ mL}) \div 103) = 1.1 \text{ kg/dm}^3$

b. $\rho = m/V$

$((0.0055 \text{ m})^3 \times \pi \times (4/3) \times 0.500 \times 1.23 \text{ kg/m}^3) + ((0.0055 \text{ m})^3 \times \pi \times (4/3) \times 0.200 \times 1.76 \text{ kg/m}^3) + ((0.0055 \text{ m})^3 \times \pi \times (4/3) \times 0.300 \times 1.41 \text{ kg/m}^3) = 9.7 \times 10^{-7} \text{ kg}$

$9.7 \times 10^{-7} \text{ kg} \div ((0.0055 \text{ m})^3 \times \pi \times (4/3)) = 1.4 \text{ kg/m}^3$

Mass = 9.7×10^{-7} kg

Density = 1.4 kg/m^3

c. $F_B = \rho V g$

$((0.0055 \text{ m})^3 \times \pi \times (4/3)) \times (1.4/1100) \times 1100 \text{ kg/m}^3 \times 9.81 \text{ m/s}^2 = 9.6 \times 10^{-6} \text{ N}$

d. $\rho = m/V$

Salt completely dissolves in water, therefore, the volume it adds is negligible.

$(350 + 55 \text{ g}) \div (50. \text{ g} \div 2.32 \text{ g/mL} + 300. \text{ mL}) = 1.3 \text{ g/mL}$

5.

a. $V = Bh/3$

$((5.00 \text{ cm} \times 10^7)^2 \text{ x } (20.0 \text{ cm} \times 10^7)) \div 3 = 1.67 \times 10^{23} \text{ nm}^3$

b. $\rho = m/V$

$15.5 \text{ N} \div 9.81 \text{ m/s}^2 \div (((5.00/100 \text{ m})^2 \times (20.0/100 \text{ m})) \div 3) = 9{,}480 \text{ kg/m}^3$

6. Temperature is inversely proportional to the density of a substance, [0.5 points] pressure is directly proportional to the density of a substance, [0.5 points] and the amount of mass or volume of a substance don't change the density of a substance, [0.5 points] unless either is increased or decreased when the other is not in which case: mass is directly proportional to the density of a substance [0.5 points] and volume is inversely proportional to the density of a substance. [0.5 points] Extensive properties do not affect intensive properties since extensive properties rely on how much matter there is in a substance while intensive properties do not. For instance, if you added more mass of a certain substance, it would not change the substance's density due to the fact the intensive properties do not rely on how much matter there is, just to reiterate. [1.5 points] Note that inversely proportional means that the variable used doesn't increase and decrease with density, but instead increases when density decreases and decreases when density increases. Directly proportional means that the variable used does increase and decrease with density.

7.

a. $P = F/A$

$(2.00 \text{ g} \div 1000 \times 7 \times 9.81 \text{ m/s}^2) \div ((1.00 \times 10^{-3} / (2 \times 1000) \text{ m})^2 \times \pi \times 7) = 2.50 \times 10^{10} \text{ Pa}$

b. No matter the size of the target, the pressure exerted by each of the arrows will not change since the cross-sectional area of the arrow does not change and the mass of the arrow does not change.

8.

a. $\rho = m/V$

(11,875 pounds × 453.59 g) ÷ ((12.0 feet ÷ 2 × 0.3048 m)^3 × π × (4/3) × 1000) = 210. g/ML

b. $\rho = m/V$

(11,875 pounds × 453.59 g) ÷ ((12.0 feet ÷ 2 × 0.3048 m)^3 × π × (4/3) × 1000 ÷ 106) = 2.10×10^8 g/L

2.10×10^8 g/L > density of liquid gold

The ball would sink in liquid gold due to fact that its density is way higher and therefore can't float.

c. $m = \rho \times V$

1.06 g/cm^3 × ((12.0 feet ÷ 2 × 0.3048 m)^3 × π × (4/3) × 1000 ÷ 10^8) = 2.71×10^{-4} g

9. ρ_f x (percentage submerged) = ρ_{person}

1,025 kg/m^3 x 0.945 = 969 kg/m^3

10.

a. $\rho_A = m/A$

(5.0×10^{-5} g × 10^6) ÷ ((6.00 × 10) mm × (15.0 × 10) mm) = 0.0056 µg/mm^2

b. Thickness = m/V/A

(5.0×10^{-5} g) ÷ (6.5×10^{-9} g/mm^3) ÷ ((6.00 x 10) mm × (15.0 x 10) mm) = 0.85 mm

c. $\rho = m/V$

$4^3 = 64$ cm^3

((64 cm^3 – 30. cm^3) × (1.225 ÷ 10^3 g/cm^3) + 35 g) ÷ 64 cm^3 = 0.55 g/cm^3

d. $F_T = F_B - mg$

H_2O_2 density = 1.45 g/cm^3

(F_T = ((64 cm^3 × 1.45 g/cm^3) - ((64 cm^3 – 30. cm^3) × (1.225 ÷ 10^3 g/cm^3) + 35 g)) ÷ 1000 × 9.81 m/s^2 = 0.57 N

$P = P_{bottom} - P_{top}$

$P = 1{,}450\ kg/m^3 \times 9.81\ m/s^2 \times 5.5\ m - 50{,}000\ Pa =$ 28,235 Pa

11.

a. $V_{block} = m(g—a) \div (\rho_f g)$

Ethanol density = 789 kg/m³

$(4.50 \times 10^4 \times 10^{-6}\ kg) \times (9.81\ m/s^2 - 50.0/3.022\ m/s^2) \div (789\ kg/m3 \times 9.81\ m/s^2)$ $= 2.52 \times 10^{-5}\ m^3$

b. $\rho = m/V$

$(4.50 \times 10^4 \times 10^{-6} \times 2.205\ pounds) \div (2.52 \times 10^{-5}\ m^3) =$ 3,940 pounds/m³

c. It is not possible for the block to reach 1/2 of the way down the tank because the block is denser than the solution.

12.

a. 5.0 g – 0.50 g = 4.5 g

$(5.0\ g \div 1000 \times 1000) \div (4.5\ g \div 1000 \div (0.35\ kg/m^3)) = 4 \times 10^3\ t/m^3$

b. $2a \times 100 \times 4a \times 100 \times 1.5a = 120{,}000a^3$

$(4.5\ g \div 1000 \div (0.35\ kg/m^3) \div 10^6) = 120{,}000a^3$

$\sqrt[3]{((4.5\ g \div 1000 \div (0.35\ kg/m^3) \div 10^6) \div 120{,}000)} = 4.7 \times 10^{-5}$

$a = 4.7 \times 10^{-5}$

13.

a. $m = \rho \times V$

$(683\ kg + 1000x) \div (1.00\ m^3 + x) =$ 880. kg/m³

$x = 1.64\ m^3$

$1.64\ m^3 \times 1000\ kg/m^3 \times 1000 =$ 1,640,000 g

b. $V_{block} = m(g—a) \div (\rho_f g)$

Silver density = 10.49 g/cm³

$(880.\ kg + m) \div 1.00\ m^3 = 10{,}490\ kg/m^3$

m = 9,610 kg

14. 1.225 kg/m³

15.

a. $((2/100\ m)^3 \times \pi \times (4/3)) + ((2/100\ m)^2 \times \pi \times (4/100/3\ m)) + ((2/100\ m) \times (2/100\ m) \times (4/100\ m) \times 3) + ((0.05\ m)^3 \times 2) = 3 \times 10^{-4}\ m^3$

b. Answers may vary. Answers may include:
- Heating the figure to a temperature that makes the figure's density equivalent to or less than the density of water.
- Decreasing the pressure of the figure to a point that makes the figure's density equivalent to or less than the density of water.

Section 2: Liquids and Gases

16. The molecules of liquids are less spaced out than the molecules of gases. [0.5 points] There are also more forces of attraction between the molecules of liquids than gases and more kinetic energy in liquid molecules. [0.5 points] When a liquid changes its phase of matter, it does not create a new substance. [0.5 points] Examples of liquids that have a density greater than that of water include liquid blood, juice, liquid gold, and corn syrup. [0.5 points]

17. These attractive forces are called intramolecular forces. [0.5 points] As the kinetic energy of gas molecules increase, the attractive forces (intermolecular) between gas molecules increases. [0.75 points] This causes gas molecules to behave more like an ideal gas, which is a gas held at ideal gas conditions, which is high kinetic energy and low pressure. [0.75 points]

18. smaller, higher

19. lighter, inversely

20. $\rho = mP/RT$

    NH_4Cl molar mass = 53.491 g/mol

    $(53.491\ g/mol \times 1\ bar) \div (0.08314 \times 273.15\ K) = 2.36\ g/L = 2.36 \times 10^{-3}\ g/mL$

21. # of molecules = # of moles × # of atoms × Avogadro's number

    $n = PV/RT$

    84 degrees Fahrenheit = about 302.04 K

    $(1\ atm \times 1\ L \times 0.78084) \div (0.0821 \times 302.04\ K) \times (2\ atoms\ (N2) \times 6.022 \times 1023) = 3.8 \times 10^{22}$ particles

22. $n = PV/RT$

    $P = nRT/V$

    $(1\ atm \times ((10/100\ m)^2 \times \pi \times 2.0\ m)) \div (8.206 \times 10^{-5} \times 273.15\ K) \times 5.0\ cylinders = 14.016$ moles

    $(14.016\ moles \times (8.314 \times 10^{-5}) \times 313.15\ K) \div ((10/100\ m)^2 \times \pi \times 2.0\ m) = 5.8\ bar$

23. $V = nRT/P$

    Br_2 molar mass = 159.808 g/mol

(2,500/1000 g ÷ 159.808 g/mol × 62.4 × 274.817 K) ÷ 1000. mm Hg ÷ 1000 = 2.7×10^{-4} cm^3

24. $V_2 = V_1T_2/T_1$

    10. L × 310 K ÷ 350 K = 8.857 L

    # of molecules = # of moles × # of atoms × Avogadro's number

    n = PV/RT

    (5.5 bar × 8.857 L) ÷ (0.08314 × 310 K) × (1 (gas is monoatomic) atom × 6.022×10^{23}) = 1.1×10^{24} particles

25. P = nRT/V

    Hydrogen gas (H_2) molar mass = 2.016 g/mol

    Butane gas (C_4H_{10}) molar mass = 58.124 g/mol

    Propane gas (C_3H_8) molar mass = 44.097 g/mol

    15 g ÷ 2.016 g/mol × 8,314 × 294.65 K ÷ 4.49 L = 4,100,000 Pa

    30. g ÷ 58.124 g/mol × 8,314 × 294.65 K ÷ 4.49 L = 280,000 Pa

    50. g ÷ 44.097 g/mol × 8,314 × 294.65 K ÷ 4.49 L = 620,000 Pa

    Partial Pressure of H_2 = 4,100,000 Pa

    Partial Pressure of C_4H_{10} = 280,000 Pa

    Partial Pressure of C_3H_8 = 620,000 Pa

26. H_2 molar mass = 2.016 g/mol

    $AgNO_3$ molar mass = 169.874 g/mol

    (x) (2.016 g/mol) = (8.00 moles) (169.874 g/mol)

    x = 674 moles

27. V = nRT/P

    Ratio of volumes = 1 volume CH_4 : 2 volumes O_2

    CH_4 molar mass = 16.043 g/mol

    800.0 g ÷ 16.043 g/mol × 0.0821 × 205 K ÷ 5.00 atm = 168 L

    168 L × 2 = 336 L

28. V = nRT/P

    2.45 moles × 0.0821 × 363.15 K ÷ 2.3 atm = $32\ dm^3$

29. $T_2 = T_1P_2V_2/P_1V_1$

    2026.5 kPa – 500.0 kPa = 1526.5 kPa

    (300. K × 1526.5 kPa × (2.3 × 10^4 cm^3 ÷ 2.5)) ÷ (2026.5 kPa × (2.3 × 104 cm^3)) – 273.15 = -47.17˚C

Section 3: Concentrations

30. ρ = m/V

    5.50 g/mol × 1.00 mole ÷ 2.5 L = 2.2 g/L

    P = nRT/V

    1.00 mole × 8.314 × 338 K ÷ 2.5 L = 1,100 kPa

    ρ = 2.2 g/L

    P = 1,100 kPa

31. A concentration is a measure of how abundant a certain property of a substance, such as its mass, is in a mixture. [0.5 points] Concentrations can be used to determine the amount of lead in a sample of tap water, the amount of carbon dioxide in the air composition of the atmosphere, the amount of salt in a saltwater solution, etc. [0.75 points] Some units of concentrations include mol/L, mol/kg, mol/mol, ppm, ppb, ppt, etc. [0.75 points]

32. particle percent = particles of salt/particles of solution

    NaCl molar mass = 58.443 g/mol

    H2O molar mass = 18.016 g/mol

    (40.0 g ÷ 58.443 g/mol × (6.022 × 10^{23} particles)) ÷ ((40.0 g ÷ 58.443 g/mol × (6.022 × 10^{23} particles)) + (100.0 g ÷ 18.016 g/mol × (6.022 × 10^{23} particles))) × 100 = 11.0%

33.
    a. M = moles of solute/volume (L) of solution

       CH_3COOH molar mass = 60.022 g/mol

       (200. mL × 0.150 × 1.05 g/cm^3 ÷ 60.022 g/mol) ÷ (200. mL ÷ 1000) = 2.62 moles/L

    b. m = moles of solute/mass (kg) of solvent

       Percent decrease = (original value – new value)/original value × 100

(200. mL $\times$ 0.150 $\times$ 1.05 g/cm^3 $\div$ 60.022 g/mol) $\div$ (200. mL $\times$ 0.85 $\div$ 1000) = 3.09 m

((200. mL $\times$ 0.150 $\times$ 1.05 g/cm^3 – 25.0 g) $\div$ 60.022 g/mol) $\div$ (200. mL $\times$ 0.85 $\div$ 1000) = 0.637 m

(3.09 m – 0.637 m) $\div$ 0.637 m x 100 = 385%

34. 2.00 $\times$ 10^{-4} g $\div$ 80.0 mL x 100 = 2.50 x 10^{-4}%

35. (14.5 m/2)2 $\times$ π $\times$ 1.50 m = 2.477 m3

(3.50 cm/100/2)^3 $\times$ π $\times$ (4/3) $\times$ 13 spheres $\times$ (2,570 kg $\div$ 2.477 m^3 $\times$ 1.75) = 0.5299 kg

0.5299 kg $\times$ 10^6 $\div$ 2570 kg = 206.19 ppm

(0.5299 kg $\times$ 1000) $\div$ (2.477 m^3 $\times$ 1000) = 0.214 g/L

The concentration of the solute in this solution is not greater than the concentration of salt in the ocean.