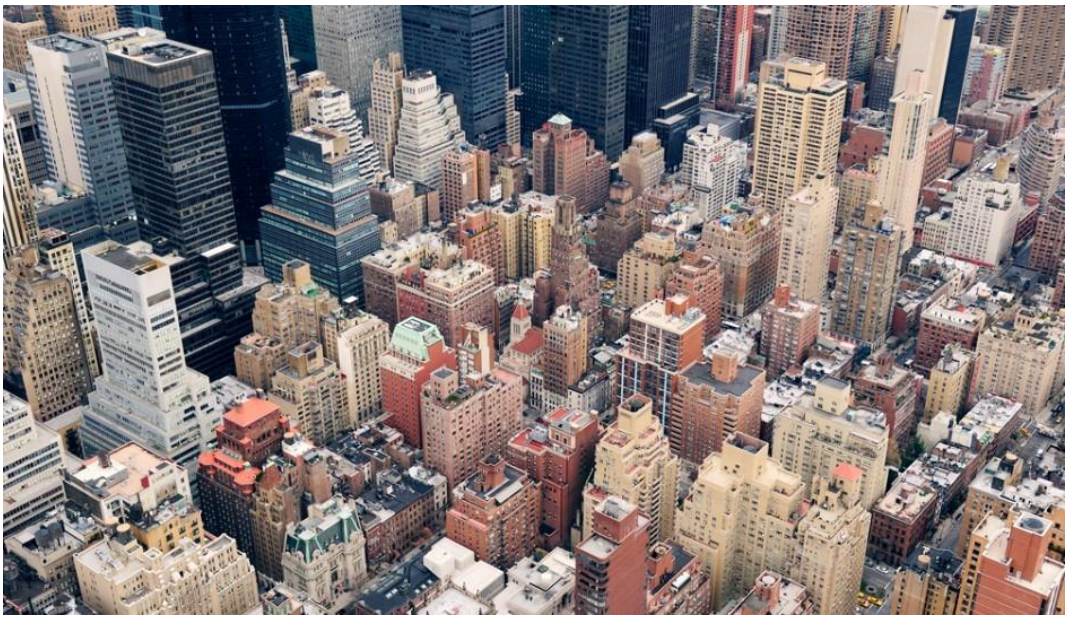
SSSS Density Lab

Division B Event

By syo_astro



Directions

*** The test involves questions relating to the physics of density [following the 2018 trial rules: https://www.soinc.org/sites/default/files/uploaded_files/Density_BC19_091917.pdf].**

*** Each question is worth 1 point unless otherwise stated. The test is 60 points and 25 minutes.**

*** Use correct units. A numerically correct answer without necessary units is given a ½ point.**

*** Don't be afraid to (logically) guess for partial credit, and read all parts of questions. Some parts may be easier and not require previous parts.**

*** Ties are broken by the following questions applied in order: 39v, 7, 31, 13, 29, 34ii, 35, 21, 9, total of 1 and 40**

1. Matching – On your answer sheet, write the roman numeral of the definition that best describes a given unit. Note that a single definition is allowed to match with multiple units, and each correct answer is worth 0.5 points [4 points].

Unit	Definition
a. M	I. The unit for number density.
b. g/L	II. The unit for volume concentration.
c. $1/m^3$	III. The concentration of a solution expressed in terms of numbers.
d. m^3/m^3	IV. The concentration of a solute in a solution.
e. Kg/kg	V. The concentration of a solution expressed in terms of mols.
f. mol/kg	VI. The concentration of a solution expressed in terms of mass.
g. Molecules per cm^3	VII. The density of a chemical component of a mixture.
h. mol/mol	VIII. This compares the amount of solute to the mass of solvent.

2. You have a completely filled cup with a volume of $2.50 * 10^{-4}$ m^{-3}. Assuming there are $8.36 * 10^{24}$ molecules of water in such a cup, what would the number density of the water molecules be in molecules / m^3?

3. What is the number density of Hydrogen atoms in the Milky Way Galaxy in atoms / cm^3? Assume that there are 6.65×10^{65} atoms of Hydrogen in the Milky Way, and the Milky Way is a cylinder that has a radius of 4.73×10^{22} cm as well as a height of 9.46×10^{20} cm.

4. What is the area density of a sheet of paper with a mass of 80.0 kg and an area of 1.00 m^2, in kg/m^2?

5. What is the length of a sheet of aluminum foil with a density of 2.70 g/cm^3 and an area density of 144.5 g/cm^2, in cm?

6. Drano consists of liquid lye and sodium hypochlorite. If the solution has a percent mass of 5.0% of sodium hypochlorite, and one has 20. grams of liquid lye, then what is the mass of sodium hypochlorite needed to mix Drano, in g?

7. A saline solution has some mass of NaCl dissolved in water. What is the mass/volume percent if 2.32 grams of NaCl are dissolved in 78 mL of water?

8. What is the volume percent of a solution consisting of 2.23 L of solute dissolved into 3400 mL of solution?

9. Which of the following involves a situation where the "parts per notation" would be useful (circle the correct response):
   A) Comparing the mass of pollen with the volume of air.
   B) Comparing the mass of arsenic in a mass of water.
   C) The number pulses an electrical signal makes per second.
   D) The speed of a jogger in meters per second.

10. What is the gas concentration of carbon dioxide molecules in the atmosphere in ppm if for every 1 million gas molecules of air, there are 400 carbon dioxide molecules?

11. A 113 g sample of tap water is tested for lead contamination. You determine that there are 1.36×10^{-6} g of lead in the sample. What is the concentration of lead in this tap water in ppb?

12. In the case of sugar and water, sugar dissolves in water. Which of the two substances is the solute?

13. What is the mole fraction of a 10 M solution that contains 1 M of NaCl?

14. What is the molarity of a solution consisting of 2.12 mols of NaOH in 0.822 L of solution, in M?

15. If you double the number of moles of solute in your solution, by what factor does the molarity change?

16. What is the molarity of a solution consisting of 3.04 g of NaCl dissolved in enough milk to make 238 mL of solution, in M? Use that NaCl has a molecular weight of 58.44 g/mol.

17. You have two ammonia solutions. One has a molarity of 0.30 M and a volume of 100 mL, while the other has and a molarity of 0.8 M and a volume of 50. mL. What is the molarity if the two ammonia solutions are mixed, in M?

18. You have a 1.00 M solution of sulfuric acid with a density of 1.08 g/mL. What is the molality of this solution, in m? Use that the molecular weight of sulfuric acid is 98.09 g/mol.

19. A test packet is 1 kg on Earth, what is its mass on Mars in kg?

20. A person weighs 803.6 Newtons, what is its mass on Earth in kg? Note: Use acceleration of gravity equals to 9.8 m/s^2.

21. A person's mass is reduced by half. By what factor does the person's density change?

22. A person has a density of 985 kg/m^3. What is the density of the person on Mars in kg/m^3?

23. You have a blood donation that is 4.48 L and has a mass of 4.75 kg. Based on this sample, what is the density of human blood in kg/m^3?

24. Bronze is an alloy made from mixing copper and tin. You have a piece of bronze that is 12% tin. What is the density of the bronze in g/cm^3 if copper has a density of 8.96 g/cm^3 and tin has a density of 7.31 g/cm^3?

25. If you bring water to a boil, will it be more or less dense than if it was liquid?

26. If you double the pressure of a gas, by what factor will its density, ρ, change?

27. A cube of cork has a density of 200 kg/m^3, while water has a density of 1000 kg/m^3. Will the cork sink or float?

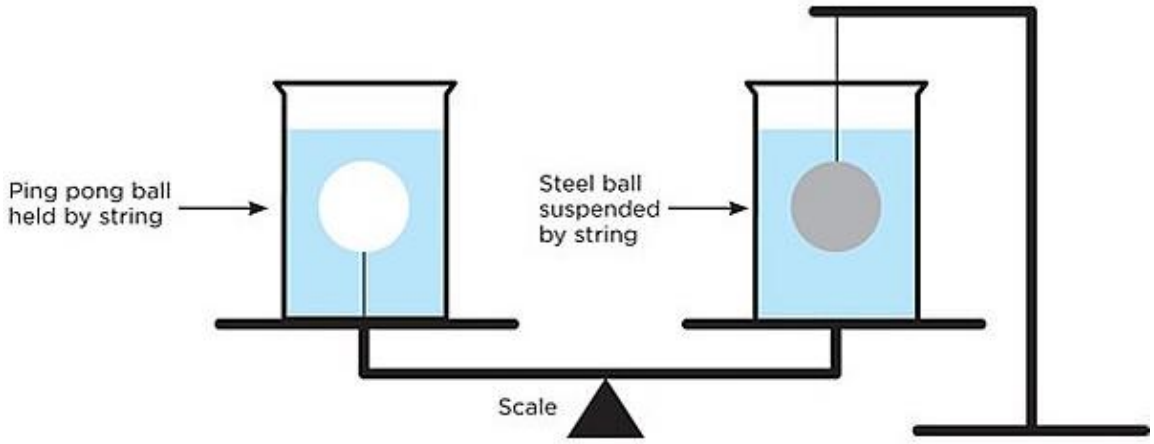
28. What is the relative density of the cork compared with the water using the densities from the previous question?

29. A rubber duck is placed in a liquid and floats, but it is not water. The buoyant force on the duck is measured to be 0.423 N, the acceleration due to gravity is 9.8 m/s^2, and the volume of liquid that the duck displaced is approximately 30 cm^3. What is the density of the liquid the duck was placed in, in kg/m^3?

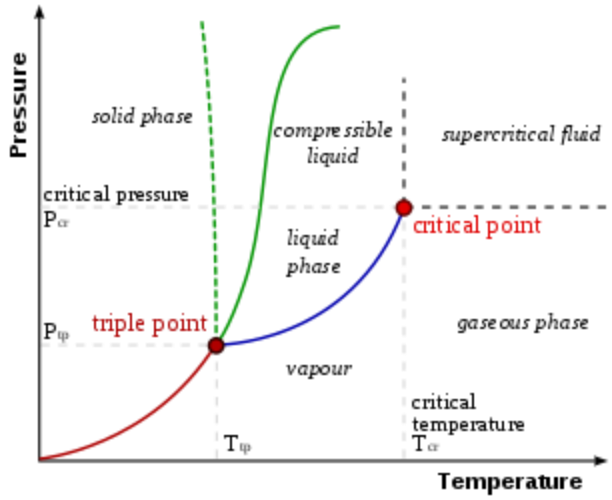
30. Is fluid pressure greater or smaller towards the bottom of a fluid?

31. As temperature increase does the density of a liquid increase or decrease?

32. Based on the previous question, would the buoyant force acting on a solid placed in a liquid increase or decrease with temperature?



33. In the picture shown above, which side would the scale tip towards, the right or the left?



34. For the following questions, refer to the <u>phase diagram of water</u> above.
    (i) Does moving vertically up in the diagram cause an increase or decrease in density?
    (ii) Does moving horizontally left in the diagram cause an increase or decrease in density?
    (iii) Is your answer to part (ii) typical of most substances? Why or why not? In your explanation, make sure to note how temperature affects a substance in relation to density. [2 points]
    (iv) What mathematical property of the curves or lines in the diagram indicate whether the phase to the left of the curve will be more or less dense than that of the phase to the right?

35. What are the three assumptions required for a gas to be considered "ideal"? [3 points]

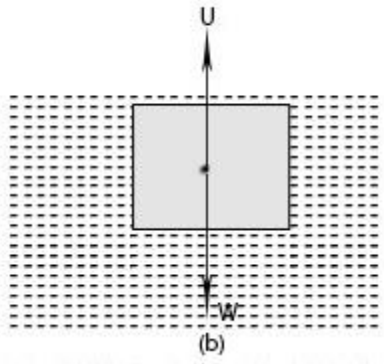
36. Which gas law relates volume and temperature?

37. If you double pressure and halve temperature of a gas, by what factor does the gas's volume change?

38. (i) What is the number density of a gas in mol/L if the gas has a pressure of 1.0 bar, a temperature of 313 K, and using an ideal gas constant of 8.314 J/(mol K)?
    (ii) What is the density of this gas in g/L if it has a molecular weight of 17.031 g/mol?

(iii) Would this substance float or sink in water?

39. (i) Based on Archimedes' Principle, if a block displaces a weight of 10 N in water, what is the buoyant force acting on the block, in N?



(ii) If the block as shown in the diagram above displaces a weight of 10 N in water (the surrounding dashes), then what is the weight of the block, in N?
(iii) This an application of what principle?
(iv) A common application of Archimedes' Principle is the submarine. Submarines contain ballasts that can be filled or emptied of water. What physical quantity is changed for the submarine when water enters into its ballasts? (Note: Be more specific than "weight")
(v) Boats similarly take advantage of this principle! Using the physical quantity from part (iv), explain why boats float. [3 points]

40. Matching – On your answer sheet, write the roman numeral of the definition that best describes a given unit. Each correct answer is worth 0.5 points [4 points].

Unit	Definition
a. Pascal	I. The amount of force that pulls on a mass.
b. Mole	II. The mass of an element or molecule.
c. Kelvin	III. The unit of the ideal gas constant.
d. kg/m^3	IV. The SI unit of mass.
e. kg	V. One Newton per square meter.
f. g/mol	VI. The number of particles in a specified amount of substance.
g. N	VII. The compactness of an object.
h. J/(mol*K)	VIII. The SI unit of temperature.