1. (2.00 pts)   Is an air mattress more or less dense when inflated? Or, does it have the same density? Explain your answer.

Expected Answer: density = m/v. same mass, greater volume when inflated so less dense when inflated

2. (2.00 pts)   What does it mean for a process to be adiabatic?

Expected Answer: no heat (Q) entering / or leaving

3. (2.00 pts)   True or false: if an object floats in water, then it must float in honey. Explain your answer.

Expected Answer: water is less dense than honey. d_w < d_h. if it floats in water d_object < d_water < d_honey so yes

4. (2.00 pts)   Which one would hurt more? Stepping on a single thumbtack or stepping on many thumbtacks? Why?

Expected Answer: single- pressure is higher P=F/A

5. (4.00 pts)
You are on a boat with a rock in the boat. The boat is in a pool of water at some volume. You throw the rock off the boat into the pool of water. Does the overall water level increase, decrease, or remain the same? Why?

Expected Answer: less. think density of rock is greater than water and archimedes prinicple. https://physics.stackexchange.com/questions/30268/basic-buoyancy-question-man-in-a-boat-with-a-stone

6. (5.00 pts)
You are given an ideal gas of molar mass 200g/mol in a closed container. It has a volume of 8m^3, pressure of 1 kilopascal, and is at 500°C. What is the mass of the gas? Include units.

Expected Answer: PV=nRT use T in Kelvin so add 273K to 500C R = 8.314Kj/kmolK get n in kmol convert to mol then multiply by 200g/mol

7. (3.00 pts)   What is the number density of the ideal gas atoms in the container in the question above?

Expected Answer: use avogadro to convert to number of atoms (multiply mol by 6.022*10^23) then divide by volume to get number density

8. (2.00 pts)   If the mass of an object is 12kg on Earth, what is the mass of that object on the Moon? Round your answer to the nearest integer in kg.

12

9. (4.00 pts)
A rigid tank contains an ideal gas at 1227°C and a 200kPa gage. The tank is cooled until the gage pressure reads 50kPa. If the atmospheric pressure is 100kPa, what is the final temperature of the gas in degrees Celsius?

Expected Answer: https://tbp.berkeley.edu/exams/4574/download/ inspired from number 3 here

10. (3.00 pts)   Assume constant amount of gas.

Charles' Law corresponds with constant _____A_____

Boyle's Law corresponds with constant _____B_____

Gay-Lussac's Law corresponds with constant _____C_____

- ◉ A) A = Pressure, B = Temperature, C = Volume
- ○ B) A = Pressure, B = Volume, C = Temperature
- ○ C) A = Volume, B = Temperature, C = Pressure
- ○ D) A = Volume, B = Pressure, C = Temperature
- ○ E) A = Temperature, B = Pressure, C = Volume
- ○ F) A = Temperature, B = Volume, C = Pressure

11. (2.00 pts)
When you go on a trip to Yosemite and take a bag of chips with you, you will notice that the higher the elevation, the more the bag of chips wants to expand. Which law/principle best describes this phenomenon?

○ A) Charles

◉ B) Boyles

○ C) Gay Lussac

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12. (2.00 pts) Solids are _____ dense than liquids.

○ A) always more

○ B) always less

◉ C) typically more

○ D) typically less

---

13. (1.00 pts) What is the SI unit for temperature?

○ A) Rankine

○ B) Fahrenheit

◉ C) Kelvin

○ D) Celcius

---

14. (5.00 pts)
Assume we are on Earth and a bathtub of some liquid is filled to the brim. 10N of liquid overflows when an object is placed into the bathtub, and the volume of that overflowed fluid is $2m^3$. What is the density of the fluid in kg/m^3?

Expected Answer: mg = density Vg 10 = denisty *2*9.81

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15. (2.00 pts) If the molarity of a solution is 2M and the moles of solute is 0.01mol, then what is the volume of the solution in L?

Expected Answer: Molarity = mol of oslute / volume

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16. (3.00 pts) How many grams of salt must be added to 1000mL of water to make a solution that is 10% salt by mass?

○ A) 90.9 g
○ B) 95.6 g
○ C) 99.9 g
○ D) 100.0 g
○ E) 101.0 g
◉ F) 111.1 g

---

17. (1.00 pts) What does it mean for a process to be isobaric?

○ A) Absence of phase transformations.

○ B) Temperature changes, given constant pressure.
○ C) Temperature is constant.
○ D) Volume is constant (synonymous with isochoric).
◉ E) Pressure is constant.
○ F) Pressure changes within 1 bar.

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18. (2.00 pts)
The density of a 3.500 wt% protein (A) solution in water (B) has been measured as 1.0351 g/cm^3 at 298K (25C). The molecular weight of the protein is 70,200 g/mol. Calculate the mass in grams of water in 1 liter of solution at 277 K. (Assume the density of water at 277 K is 1.0000 g/cm^3.)

○ A) 0.997 g B
○ B) 0.998 g B
○ C) 0.999 g B
○ D) 9.98 g B
○ E) 99.8 g B
◉ F) 998.9 g B

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19. (4.00 pts)
The void ratio (e) of a soil is equal to the volume of non-solids (i.e., the voids) divided by the volume of solids. One the other hand, the porosity (n) of a soil is the equal to the volume of voids divided by the total volume of the soil. What is the relationship between e and n?

○ A) $e = \frac{n+1}{n}$
○ B) $e = \frac{n-1}{n}$
○ C) $e = \frac{1}{n-1}$
○ D) $e = \frac{1}{1-n}$
◉ E) $e = \frac{n}{1-n}$
○ F) $e = \frac{\sqrt{n+1}}{n}$

---

20. (4.00 pts) Refer to Question 19. Assume quartz has a specific gravity 2.65. If a dry quartz sand has a density of 1.96 g/cm^3, which of the following is correct?

○ A) $e = 0.306$
○ B) $e = 0.322$
◉ C) $e = 0.352$
○ D) $n = 25.2\%$
○ E) $n = 23.8\%$
○ F) $n = 22.0\%$

---

21. (6.00 pts)
Refer to Questions 19 and 20. Now define the degree of saturation, S, as the volume of water (occupying the voids) divided by the total volume of the voids in a soil. A quartz sand has $S = 25\%$ and density 1.88 g/cm^3 is compacted using a hammer to produce a denser soil. The compacted soil has density 2.28 g/cm^3. What are e and S, respectively? Assume the specific gravity of water = 1.00.

○ A) $e = 0.246$, $S = 46\%$
○ B) $e = 0.237$, $S = 51\%$
◉ C) $e = 0.214$, $S = 55\%$
○ D) $e = 0.179$, $S = 62\%$
○ E) $e = 0.155$, $S = 48\%$
○ F) None of these, or not enough information

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22. (1.00 pts) Which gas law(s) show that for gases, temperature and pressure have a proportional relationship?

○ A) Boyle's Law
○ B) Charles' Law
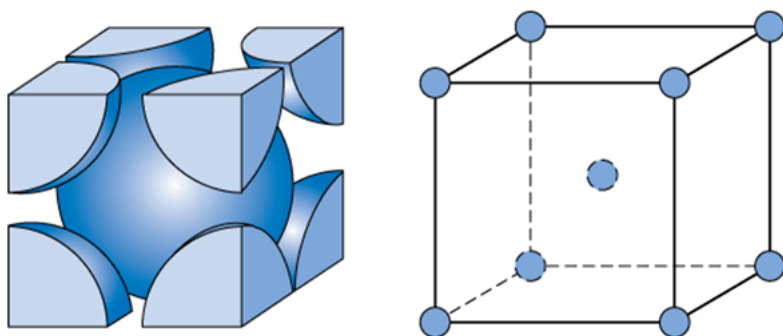○ C) Gay-Lussac's Law
○ D) Ideal Gas Law

○ E) Charles' Law and Ideal Gas Law
◉ F) Gay-Lussac's Law and Ideal Gas Law

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23. (1.00 pts)   What is true about the processes going on inside the earth?

◉ A) Denser material is still sinking towards the core.
○ B) The layers in the deep Earth are at equilibrium.
○ C) Oceanic crust is denser than the mantle, making it unstable.
○ D) Hydrogen gas is depleted inside the mantle.
○ E) Lighter elements through potassium are absent in the core.
○ F) None of these.

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24. (3.00 pts)
At room temperature, iron normally has a body-centered cubic (BCC) structure called *ferrite*. The picture shows a BCC repeating unit. Calculate the fraction of space occupied by atoms (the "volume density") for a BCC crystal. Assume atoms are like spheres.

○ A) 0.54
○ B) 0.56
○ C) 0.65
◉ D) 0.68
○ E) 0.71
○ F) 0.74

---

25. (2.00 pts)
Refer to Question 24. When iron heats up to a bright-orange color, it transforms into a face-centered cubic (FCC) structure called *austenite*. The picture shows an FCC repeating unit with four pieces removed for clarity (i.e., three hemispheres and one quarter-hemisphere nearest you are not shown). How many more neighbors does an atom of iron bond with in its austenite form than in its ferrite form?

○ A) Less than 0; austenite has fewer neighboring atoms
○ B) 0
○ C) 1
○ D) 2
◉ E) 4
○ F) None of these, or not enough information

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26. (4.00 pts)   Refer to Questions 24 and 25. If the room temperature density of ferrite is 7.87 g/cm^3, calculate the hypothetical room temperature density of austenite.

○ A) 7.42
○ B) 7.67
○ C) 7.98
○ D) 8.26
◉ E) 8.56
○ F) 8.87

27. (1.00 pts) A rod is struck by hammer along its length. Sound waves not only travel through the air, but also inside the rod. Is the density of the rod the same at all points?

- ○ A) Yes, because sound waves travel through valence shell electrons, unlike bulk motion of a gas.
- ○ B) Yes, because sound waves are discretized into phonons which propagate through non-classical degrees of freedom.
- ○ C) Yes, because sound waves cause localized Joule heating, which for a solid is practically at the same density.
- ◉ D) No, because sound waves cause bulk motion, like the bulk motion of a gas.
- ○ E) No, because sound waves take up quantized density of states similar to a 2-D film perpendicular to the wave direction.
- ○ F) No, because sound waves cause localized heating near the Rankine-Hugoniot limit.

28. (3.00 pts)
A carpenter builds a new building floor with a foundation, followed by two layers of support, a subsurface deck, and a top deck. Without specifying units, the thicknesses the layers ar 1.25, 0.63, 0.50, 1.13, and 0.45, respectively. The values of specific gravity for the layers are 2.24, 1.58, 1.64, 0.66, and 0.93, respectively. Calculate the areal density of the entire floor.

- ○ A) 0.56
- ○ B) 0.69
- ◉ C) 1.46
- ○ D) 1.59
- ○ E) 1.78
- ○ F) Not enough information exists to answer the question

29. (2.00 pts) Which list of substances is properly sorted completely by descending order of density? Assume standard temperature and pressure.

- ○ A) Rock salt, cellulose, francium, lithium, milk
- ○ B) Vacuum energy, neutronium, spider silk, plutonium, milk
- ○ C) 4-chlorophenol, graphite, steel, 1,2-diiodobenzene, syn-propanethial-s-oxide
- ◉ D) Carbon tetrachloride, water, sodium metal, n-hexane
- ○ E) Potassium metal, chloroform, benzene, liquid butane, nitrogen gas
- ○ F) Plutonium, neptunium, americium, iridium, curium

30. (4.00 pts)
Between 1880 and 2020, the CO_2 concentration in the atmosphere increased from 270 ppm to 410 ppm. By how much has the density of dry air increased, in ppm? Note it is defined by the change in the value divided by initial value. Assume densities for dry air and CO_2 are 1.17 g/cm^3 and 1.78 g/cm^3, respectively

- ○ A) 75
- ○ B) 79
- ◉ C) 85
- ○ D) 92
- ○ E) 114
- ○ F) 140