Solutions to CP Review Chapters 18, 20 and 21

Sample Calculations

For problems 1-10, refer to Table 18.1 on p. 261 of your textbook as necessary. For each problem, either show you work with a calculation or explain conceptually.

1. Which has greater density – one kilogram of ice or one kilogram of water (at 4°C)?

H_2O is densest at 4°C. The open structure of ice crystals makes ice less dense than water. Ice floats!

1 atm = 760 mm Hg = 101.5 kPa

2. Which has greater volume – one kilogram of lead or one kilogram of platinum? $D = \frac{m}{V}$, so $V = \frac{m}{D}$

Platinum is nearly twice as dense as lead, so the volume of an equal mass of lead will be greater

$V_{Pb} = \frac{10^3 g}{11.3 g/cm^3} = 88.5 cm^3$

$V_{Pt} = 10^3 g / 21.4 g/cm^3 = 46.7 cm^3$

3. Which has greater mass – one cubic meter of iron or one cubic meter of gold?

Gold is more dense than iron, which means gold has more mass per unit volume.

4. Which has greater density – one kilogram of lead or two kilograms of lead?

Density does not depend on the amount of mass, so both will have the same density.

5. Which has greater density – a single uranium atom or Earth? Earth's density is about $5.5 g/cm^3$ (on average) while the density of uranium is $19.0 g/cm^3$. Density is not dependent on quantity, although it does depend partly on how closely packed the atoms are, so the density of a single atom of Uranium might not be exactly $19 g/cm^3$.

6. Which has greater volume – 10 kg of lead or 5 kg of aluminum?

$V = \frac{m}{D}$ lead: 10 kg → $\frac{10 \times 10^3 g}{11.3 g/cm^3} = 885 cm^3$ Pb

aluminum: $5 \times 10^3 g / 2.7 g/cm^3 = 1.85 \times 10^3 cm$ Al ← greater volume

7. What is the specific gravity of gold?

$Sp. gravity = \frac{\text{density of substance}}{\text{density of } H_2O}$ $\frac{19.3 g/cm^3}{1.00 g/cm^3} = \boxed{19.3}$ (units cancel!)

8. What is the specific gravity of copper?

$Sp. gr = \frac{D_{Cu}}{D_{H_2O}}$ $\frac{8.9 g/cm^3}{1.00 g/cm^3} = \boxed{8.9}$

9. What is the mass of $5.4 m^3$ of aluminum?

$m = D \cdot V$ $\frac{2.7 g}{cm^3} \times \frac{5.4 m^3}{1} \times \frac{10^6 cm^3}{1 m^3} = \boxed{1.5 \times 10^7 g}$

10. What is the volume of 6.72 kg of platinum?

$V = \frac{m}{D}$ $6.72 kg \times \frac{10^3 g}{kg} = 6.72 \times 10^3 g$ $\frac{6.72 \times 10^3 g}{21.4 g/cm^3} = \boxed{3.14 \times 10^2 cm^3}$

11. What is the ***weight*** of a cubic meter of cork? The density of cork is 400 kg/m³. (Be sure to answer with weight rather than mass!) $W = mg$ $m = D \cdot V$

$W = (D \cdot V) g$ $\frac{400 kg}{m^3} \times \frac{1 m^3}{1} \times \frac{10 m}{s^2} = \boxed{4 \times 10^3 N}$ [or $3.9 \times 10^3 N$, using $\frac{9.8 m}{s^2}$]

12. Find the density of a 5-kg solid cylinder that is 10 cm tall with a radius of 3 cm.

$V = \pi r^2 h$ $\pi(3cm)^2(10cm) = 2.8 \times 10^2 cm^3$

$D = \frac{m}{V}$ $\frac{5 \times 10^3 g}{2.8 \times 10^2 cm^3} = \boxed{18 g/cm^3}$ or $\boxed{2 \times 10^1 \frac{g}{cm^3}}$ w/ sig. figs

13. The planet Saturn has a mass of 5.69×10^{26} kg and a volume of 8.01×10^{23} m^3.

a) What is the density of Saturn?

$$D = \frac{m}{V} \qquad \frac{5.69 \times 10^{26}\ kg}{8.01 \times 10^{23}\ m^3} = \boxed{7.10 \times 10^{2}\ \frac{kg}{m^3}}$$

b) Would Saturn float or sink if you could place it in a gigantic bathtub filled with water? Explain your answer with a complete sentence. Think about the balloon lab and how the relative densities of materials determine whether one will float or sink in the other.

$$D_{H_2O} = \frac{1.00\ g}{cm^3} \times \frac{1\ kg}{10^3\ g} \times \frac{10^6\ cm^3}{1\ m^3} = \frac{1.00 \times 10^3\ kg}{m^3}$$

Saturn is less dense than water, so it would float in water.

14. You are handed a 5.00×10^{-3}-kg coin and told that it is gold. You discover (by using water displacement) that the coin has a volume of 5.90×10^{-7} m^3. Is the coin really gold, or simply a good imitation? Look up the density of gold on the table in your book to help you answer the question. Show your work!

$D_{Au} = \frac{19.3\ g}{cm^3}$

$$D = \frac{m}{V} \qquad \frac{5.00 \times 10^{-3}\ kg}{5.90 \times 10^{-7}\ m^3} = 8.47 \times 10^{+3}\ \frac{kg}{m^3}$$

pure gold: $\frac{19.3\ g}{cm^3} \times \frac{10^6\ cm^3}{1\ m^3} \times \frac{1\ kg}{10^3\ g} = 1.93 \times 10^4\ \frac{kg}{m^3}$

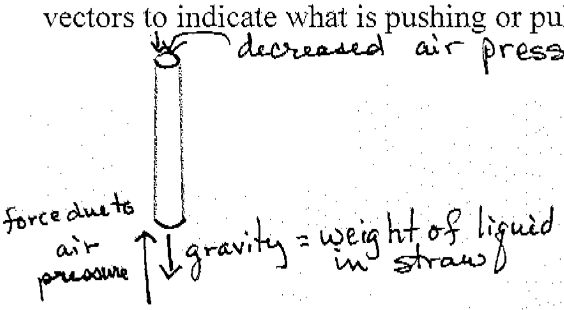
Pure gold is denser so the coin is a good imitation, but not pure gold.

15. When we compress a certain quantity of air so that its volume is cut in half, and the temperature is held constant, what happens to the pressure that the air exerts on the walls of its container? What law did you use to answer this question? What happens to the density of the air?

V and P are inversely proportional (Boyle's Law) so if volume is halved, P will double.

If V is halved (because of this increase in P, and not by leaking gas) then density of air will double — same mass in half the volume.

16. Explain what forces are acting on liquid that you drink through a straw. Draw a picture and use force vectors to indicate what is pushing or pulling on the liquid.



Force of air up on bottom of straw must be equal to or greater than the weight of the liquid plus the force of air downward at top of straw in order for liquid to stay in or accelerate up the straw.

17. Consider the balloon lab. Assume your hot air balloon had a volume of 342 Liters when the air was at a temperature of 80°C. What volume would the same amount of air occupy at room temperature, 20°C? Remember what units the temperatures need to be in to use Charles's Law!!

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

$V_1 = 342\ L$ $\quad T_1 = 80°C + 273 = 353\ K$ $\quad T_2 = 20°C + 273 = 293\ K$

$$V_2 = \frac{V_1 T_2}{T_1} = \frac{(342\ L)(293\ K)}{(353\ K)}$$

$$\boxed{V_2 = 284\ L}$$

For Problems 18-22, keep in mind that the specific heat capacity of water is 1 calorie/g°C, or 4.184 J/g°C. Think about your units!!!!

18. In 1985, 2-year-old Michael Trode was found in the snow near his Milwaukee home with a body temperature of 16.0°C. Normal human body temperature is 37.0°C. The specific heat capacity of the human body is 3470 J/kg°C. How much heat did Michael's body lose? You really need the child's mass to complete this problem, so let's assume his mass is 10.0 kg.

$q = mC\Delta T$

$q = (10.0\,kg)\left(\frac{3470\,J}{kg \cdot °C}\right)(16.0°C - 37.0°C)$

$q = -728700\,J \rightarrow \boxed{-7.29 \times 10^5\,J}$ (The negative sign indicates that heat was given off or "lost" by Michael's body.)

19. Gwyn's bowl is filled with 0.175 kg of 60.0°C soup (same specific heat capacity as water). She drops a spoon into the bowl. The specific heat capacity of the spoon is 240.0 J/kg°C. What final temperature will the spoon and soup reach if the spoon is initially at 20.0°C and has a mass of 40.0 grams? Be careful with your units!!!!

[method 1]

$0.175\,kg \times \frac{10^3\,g}{1\,kg} = 175\,g$ and $\frac{240.0\,J}{kg \cdot °C} \times \frac{1\,kg}{10^3\,g} = \frac{.2400\,J}{g \cdot °C}$

$-$heat lost by soup = heat gained by spoon

$-m_{soup}C_{H_2O}\Delta T_{soup} = m_{spoon}C_{spoon} \cdot \Delta T_{spoon}$

~~$-(175g)\left(\frac{1.00\,cal}{g \cdot °C}\right)(T_f - 60.0°) = (40.0g)\left(\frac{.240\,J}{g \cdot °C}\right)(T_f - 20.0°C)$~~

~~$-175T_f + 10500 = 9.6T_f - 192$~~

$\rightarrow 184.6\,T_f = 10692$

$\boxed{T_f = \text{~~57.9°C~~}}$

59.48°C

20. How much 5°C water must be added to 90 grams of 80°C water in order for the final temperature to be 20°C? Give your answer in grams *and* Liters.

[method 2: absolute value]

|heat lost by hot water| = |heat gained by cold water|

$mC\Delta T = mC\Delta T$

$m\left(\frac{1.00\,cal}{g \cdot °C}\right)(80° - 20°C) = (90g)\left(\frac{1.00\,cal}{g \cdot °C}\right)(20° - 5°C)$

$60m = 1350\,g$

$\boxed{m = 22.5\,g}$ ~360 g .36 L

5°C H_2O

90 g of 50°C H_2O for final temp of 20°C (23000 J)

$Q = mC\Delta T$

$= (90g)(4.184\,J/g°C)(20° - 50°C)$ 22,600 5400 cal

21. Which loses more energy: 10 grams of water cooling from 90°C to 30°C or 100 grams of iron cooling from 80°C to 20°C? Show your calculations or explain your answer conceptually. You may have to look up the specific heat capacity of iron (it's in your book, in one of the problems at the end of Chapter 21). $C_{Fe} = \frac{0.12\,cal}{g \cdot °C}$

$|q_{H_2O}| = mC\Delta T = (10g)\left(\frac{1.00\,cal}{g \cdot °C}\right)(90° \rightarrow 30°C) = 600\,cal$

$|q_{Fe}| = mC\Delta T = (100g)\left(\frac{0.12\,cal}{g \cdot °C}\right)(80° - 20°) = 720\,cal$

Iron loses more energy, (but 10 times as much iron is losing only 20% more energy)

22. I pour 50.0 mL of water at 50.0°C into a bowl containing 100.0 mL of water, and the final temperature of the mixture is 38.0°C. What was the initial temperature of the 100.0 mL of water, assuming that no heat is lost to the bowl or the atmosphere? $-$heat lost by hot water = heat gained by cold water

$(1\,mL\ H_2O = 1.0\,g\ H_2O)$

$-mC\Delta T = mC\Delta T$

$-(50.0g)\left(\frac{1.00\,cal}{g\,°C}\right)(38.0° - 50.0°) = (100.0g)\left(\frac{1.00\,cal}{g \cdot °C}\right)(38.0° - T_i)$

$-(50.0)(-12.0\,°C) = 3800 - 100T_i$

$600.°C = 3800°C - 100T_i$

$-3200°C = -100T_i$

$\boxed{T_i = 32°C}$

Note that the ΔT is half as great for 100.0 g of water as for 50.0 g of H_2O.