Answer Key

Density Lab

UT Regional 2020

Maximum possible score: 314

Lab – all questions/parts are worth 10 points each, for a total of 170 points.

Pre-Lab Questions

1.
    a. False
    b. Accept any answer between 44.0 and 44.9, inclusive. If their answer fits this range but does not have 3 significant figures, only award half credit.
    c. Meniscus
    d. Liquid molecules are more attracted to the wall of the graduated cylinder than each other.
2. If the cylinder tipped while you were in that position, its contents could splash into your face and over your body.

Measurements and Results

3. Accept any answer between 3.0 mL and 7.0 mL
4. Accept any answer between 2.3 grams and 5.5 grams
5. Accept any answer between 0.7 g/cm^3 and 0.85 g/cm^3
6. Accept any answer between 85% and 95%
7. Accept any answer between 35.0 and 45.0 mL
8. Accept any mass between 34 grams and 45 grams
9. Accept any answer between 35.0 mL and 45.0 mL
10. Accept any mass between 27 grams and 36 grams
11. Accept any answer that is less than (but within 10 mL of) the sum of their answers to #8 and #10. For example, if their answers to #8 and #10 were both 40.0 mL, then 75.0 mL would be acceptable, but 65.0 mL would not.

Post-Lab Questions

12. It is slightly less that if the volumes of the individual components were added together
13. Isopropyl alcohol molecules and water molecules are attracted to each other more than they are attracted to themselves. This causes their volume to decrease and their density to increase.
14. Macroscopically, the volume of the solution decreases. At the molecular level, that means molecules are moving closer to each other. This releases potential energy, so the mixing process is exothermic overall.

Section A – all questions are worth 2 points, for a total of 24 points.

15. C
16. A
17. B
18. B
19. B
20. A, B, C, and E
21. D
22. B
23. A
24. A
25. D
26. A

Section B – all parts are worth 4 points, for a total of 120 points.

27.
   a. Piece C
   b. All of their densities are the same
   c. Piece C

28.
   a. Accept answers between 28 and 30 Kelvin
   b. The pressure is doubled (alternative, and equally correct answer: the pressure increases to 2.4 atomospheres)

29.
   a. Accept answers between 6×10^{17} kg/m^3 and 7×10^{17} kg/m^3
   b. Accept answers between 2.5×10^{16} kg and 3.5×10^{16} kg
   c. Accept answers between 650 kg/m^3 and 700 kg/m^3
   d. Accept answers between 65% and 70%

30.
   a. 100 mL
   b. 1.426 g/mL
   c. This student is not correct. In an ideal solution, the molecules just interact, it's just that all of the interactions are the same, even if the molecules are different compounds.
   d. They both have the same types of intermolecular forces (LDFs, Dipole-Dipole).

31.
   a. Down
   b. Accept answers between 580 Newtons and 620 Newtons
   c. Accept answers between 5.8×10^7 Pa and 6.2×10^7 Pa
   d. In general, increasing pressure decreases the melting point of water (for moderate pressures). However, the increase in pressure from the skater's weight would only result in a very small change in the melting temperature of water. Based on the red vertical red line at 0°C, it is reasonable to estimate that the melting point would decrease by a fraction of a degree. According to the problem, skating is possible at -15°C, which is much colder. As a result, the pressure due to the skater's weight is not enough to explain this phenomenon.
   e. The slope is negative because ice is less dense than water. The slope is very steep because this difference is very small.

32.
   a. It decreases
   b. It increases
   c. Intermolecular attractions
   d. Methane will have larger values for both *a* and *b*. Both compounds only have LDFs, but methane is more massive, so its LDFs will be stronger, resulting in a larger value for *a*. Similarly, methane is also much bigger, so it will have a larger value for *b*.
   e. Toluene doesn't have hydrogen bonding, but it will have extensive π-stacking. This makes its overall intermolecular forces stronger than those of ethanol. Bit of a trick question that's far beyond the scope of this event; I just included it for those who are really into chemistry like I am.

33.
   a. The temperature stays constant
   b. It would make it harder for light/heat to escape

c. Increase! The process will no longer be isothermal. As the cloud contracts, heat will stay trapped in the cloud since it's so dense, causing the cloud's temperature to rise.
d. Since the cloud will be heating up as it contracts, it will take more work to compress it, since pressure will be building up.
e. The entropy will stay constant since no heat is exchanged with its surroundings! This is essentially describing a reversible adiabatic compression. Again, far beyond the scope of this event, and just included for fun.

34.

a. When the galaxies are spheres, the collisions will "look" the same regardless of the orientation of the galaxies. However, when the galaxies are modelled as disks, their cross-sectional area in the direction of a collision will be different for each galaxy depending on their relative orientations (imagine the case where two disks collide edge-on as opposed to face-on as an extreme). The average cross-sectional would be smaller in the second model, increasing the mean free path and mean time between collisions.
b. An attractive force between the galaxies would reduce the mean free path and mean time between collisions. This effect will be more pronounced at lower velocities, when the attractive force between the particles results in a larger fractional change in the velocity ($\Delta v/\langle v \rangle$) of each individual galaxy.