

## EXPLANATION SHEET

### MCQ

1. Look for a molecule that is nonpolar and has a low molar mass.
2. Use Combined Gas Law
  - a.  $P_1V_1 / T_1 = P_2V_2 / T_2$
  - b.  $PV / T = (3P)(xV) / (1/2T)$
  - c.  $x = 1/6$
3. Use  $MM = dRT / P$ 
  - a.  $MM_{O_2} = dRT / P = (0.02500 \text{ g} / 0.0175 \text{ L})(0.08206 \text{ Latm/molK})(300.15 \text{ K}) / (1.000 \text{ atm}) = 35.17 \text{ g/mol}$ 
    - i.  $17.50 \text{ mL} = 0.0175 \text{ L}$
    - ii.  $27.0 \text{ C} = 300.15 \text{ K}$
4. Since he measures the temperature in Celsius, his mistake does not affect the results too much because Kelvin is used in the equation, offsetting the error.
5. Since the problem does not give nor does not ask for the actual size of each city, any numbers can be used. In the following example calculation, the size of the smallest city, Anthrax, is 2.
  - a. Doune:  $12900 \text{ people} / 6 \text{ area} = 2150 \text{ people/area}$
  - b. Camelot:  $14000 \text{ people} / 3 \text{ area} = 4666.67 \text{ people/area}$
  - c. Anthrax:  $11300 \text{ people} / 2 \text{ area} = 5650 \text{ people/area}$
6. Use the formula for molarity and some stoichiometry.
  - a.  $n_{NaOH} = n_{HCl}$ 
    - i. 1:1 ratio of NaOH to HCl
  - b.  $n_{HCl} = VM_{HCl} = (15.00 \text{ mL})(3.00 \text{ M}) = 45 \text{ mmol}$
  - c.  $n_{NaOH} = 45 \text{ mmol} / 5.00 \text{ M} = 9.000 \text{ mL}$
7. Pressure is dependent on height and since both tanks have the same height, the pressure on the valve is the same in both tanks.
8. Use formula for molarity
  - a.  $n_{KCl} = V_{initial}M_{KCl} = (15.0 \text{ mL})(4.00 \text{ M}) = 60.0 \text{ mmol}$
  - b.  $V_{new} = n_{KCl} / M_{new} = 60.0 \text{ mmol} / 2.50 \text{ M} = 24.0 \text{ mL}$
  - c.  $\Delta V = V_{new} - V_{initial} = 24.0 \text{ mL} - 15.0 \text{ mL} = 9.0 \text{ mL}$
9. Use  $MM = dRT / P$ 
  - a.  $d_{O_2} = MMP / RT = (32.00 \text{ g/mol})(0.750 \text{ atm}) / (0.08206 \text{ Latm/molK})(263.15 \text{ K}) = 1.11 \text{ g/L}$ 
    - i.  $-10. \text{ C} = 263.15 \text{ K}$

10. Find the volume of the jar

- a.  $V_{\text{jar}} = \pi r^2 h = \pi * (2.5 \text{ cm})^2 * (10 \text{ cm}) = 196 \text{ cm}^3$
- b. Since there cannot be a perfect fit of beans, round down to 180 beans.

FRQ

1. See answer key

2. See answer key

3. See answer key

4. See answer key

5. Use formula for molarity

- a.  $M_{\text{NaCl}} = n_{\text{NaCl}} / V = (0.1711 \text{ mol NaCl}) / (0.500 \text{ L}) = \mathbf{0.342 \text{ M NaCl}}$ 
  - i.  $n_{\text{NaCl}} = m / \text{MM} = (10.0 \text{ g}) / (58.440 \text{ g/mol}) = 0.1711 \text{ mol}$
  - ii. There are three significant figures because 10.0 g has three and the volume of water is exact when a volumetric flask is used.

6. See answer key

7. Use formula for buoyancy force

- a.  $F_b = d_{\text{water}} g V_{\text{displaced}} = (0.00100 \text{ kg/cm}^3)(9.81 \text{ m/s}^2)(64 \text{ cm}^3) = \mathbf{0.63 \text{ N}}$ 
  - i.  $V_{\text{displaced}} = (4.0 \text{ cm})^3 = 64 \text{ cm}^3$

8. Use formula for buoyancy force

- a.  $F_b = d_{\text{water}} g V_{\text{displaced}} = (0.00100 \text{ kg/cm}^3)(9.81 \text{ m/s}^2)(40. \text{ cm}^3) = \mathbf{0.39 \text{ N}}$

9. Use  $F = ma$ ,  $d = m / V$

- a.  $F_{\text{net}} = F_g + F_b = (m_{\text{object}})(-g) + d_{\text{water}} g V_{\text{displaced}} = (m_{\text{object}})(-9.81 \text{ m/s}^2) + (0.00100 \text{ kg/cm}^3)(9.81 \text{ m/s}^2)(40. \text{ cm}^3) = (-9.81 m_{\text{object}}) \text{ N} + 0.39 \text{ N}$
- b. Divide everything by  $m_{\text{object}}$
- c.  $a_{\text{net}} = -9.81 \text{ m/s}^2 + (0.39 \text{ N}) / m_{\text{object}} = -0.50 \text{ m/s}^2$ 
  - i.  $a_{\text{net}} = 2\Delta y / t^2 = (2)(-1.0 \text{ m}) / (2.0 \text{ s})^2 = -0.50 \text{ m/s}^2$
  - ii.  $m_{\text{object}} = 0.042 \text{ kg} = 42 \text{ g}$
- d.  $d_{\text{object}} = m_{\text{object}} / V_{\text{object}} = (42 \text{ g}) / (40. \text{ cm}^3) = \mathbf{1.1 \text{ g/cm}^3}$

10. Use Ideal Gas Law

- a.  $V = nRT / P = (0.0195 \text{ mol})(0.08206 \text{ Latm/molK})(303.15 \text{ K}) / (0.974 \text{ atm}) = \mathbf{0.498}$

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- i.  $(3.00 \text{ g}) / (153.81 \text{ g/mol}) = 0.0195 \text{ mol}$
- ii.  $30. \text{ C} = 303.15 \text{ K}$
- iii.  $(740. \text{ torr}) / (760 \text{ torr/atm}) = 0.974 \text{ atm}$

- iv. There are three significant figures because when you convert C to K, you are adding, which increases the significant figures of the temperature from 2 to 3.

11. Use Dalton's Law of Partial Pressures, Boyle's Law

- a.  $P_{\text{total}} = P_{\text{Gas1}} + P_{\text{Gas2}} + P_{\text{Gas3}} = 2.0 \text{ atm} + 1.5 \text{ atm} + 4.0 \text{ atm} = 7.5 \text{ atm}$   
 b.  $P_2 = P_1 V_1 / V_2 = (7.5 \text{ atm})(9.5 \text{ L}) / (8.0 \text{ L}) = \mathbf{8.9 \text{ atm}}$   
 i.  $V_1 = V_{\text{Gas1}} + V_{\text{Gas2}} + V_{\text{Gas3}} = 3.0 \text{ L} + 2.0 \text{ L} + 4.5 \text{ L} = 9.5 \text{ L}$

12. Use formula for specific gravity

- a.  $G_{\text{object}} = W_{\text{in air}} / (W_{\text{in air}} - W_{\text{in water}}) = (0.1825 \text{ N}) / (0.1825 \text{ N} - 0.15 \text{ N}) = \mathbf{5.6}$   
 i.  $W_{\text{in air}} = gm = (9.81 \text{ m/s}^2)(0.01860 \text{ kg}) = 0.1825 \text{ N}$   
 1.  $18.60 \text{ g} = 0.01860 \text{ kg}$

HANDS-ON PORTION

Station 1

- Use formula for density
  - $d = m / v = (19.08 \text{ g}) / (9 \text{ mL}) = 2 \text{ g/mL}$
  - The graduated cylinder limits the significant figures to one:  $71 \text{ mL} - 62 \text{ mL} = 9 \text{ mL}$
- Specific gravity is density of the object compared to the density of, in this case, water, so 2 (without units)
- Use formula for specific gravity
  - $G_{\text{object}} = W_{\text{in air}} / (W_{\text{in air}} - W_{\text{in water}})$
  - $W_{\text{in water}} = W_{\text{in air}} - W_{\text{in air}} / G_{\text{object}} = 0.1872 \text{ N} - (0.1872 \text{ N}) / ((19.08 \text{ g}) / (9 \text{ mL})) = 0.1 \text{ N}$   
 i.  $W_{\text{in air}} = gm = (9.81 \text{ m/s}^2)(0.01908 \text{ kg}) = 0.1872 \text{ N}$   
 1.  $19.08 \text{ g} = 0.01908 \text{ kg}$
- See answer key

Station 2

- Use formula for density
  - $d = m / v = (16.26 \text{ g}) / (1.8 \text{ cm} * 3.4 \text{ cm} * 1.0 \text{ cm}) = 2.7 \text{ g/cm}^3$
  - The rulers limit the number of significant figures to two.
- Use formula for density
  - $d = m / v = (43.91 \text{ g}) / (2.1 \text{ cm} * (3.6 \text{ cm})^2 * \pi) = 0.51 \text{ g/cm}^3$
  - The rulers limit the number of significant figures to two.
- Use formula for density
  - $d = m / v = (77.02 \text{ g}) / (4/3 * \pi * (2.3 \text{ cm})^3) = 1.5 \text{ g/cm}^3$
  - The rulers limit the number of significant figures to two.
- Compare the densities of the objects to the density of water. Use the formula for force of buoyancy.
  - $d_{\text{water}} = 1.00 \text{ g/cm}^3$   
 i. Objects A and C will sink

- b. Object A:  $F_b = d_{\text{water}} g V_{\text{displaced}} = (0.00100 \text{ kg/cm}^3)(9.81 \text{ m/s}^2)(1.8 \text{ cm} * 3.4 \text{ cm} * 1.0 \text{ cm}) = 0.060 \text{ N}$   
 i. The rulers limit the number of significant figures to two.
- c. Object C:  $F_b = d_{\text{water}} g V_{\text{displaced}} = (0.00100 \text{ kg/cm}^3)(9.81 \text{ m/s}^2)(4/3 * \pi * (2.3 \text{ cm})^3) = 0.50 \text{ N}$   
 i. The rulers limit the number of significant figures to two.

### Station 3

- Use ratios
  - $d_{\text{water}} / W_{\text{water}} = d_{\text{oil}} / W_{\text{oil}} \rightarrow W_{\text{oil}} = d_{\text{oil}} / (d_{\text{water}} / W_{\text{water}}) = (0.93 \text{ g/mL}) / ((1.00 \text{ g/mL}) / (0.25 \text{ N})) = 0.23 \text{ N}$
- Use ratios
  - $d_{\text{water}} / W_{\text{water}} = d_{\text{unknown}} / W_{\text{unknown}} \rightarrow d_{\text{unknown}} = (W_{\text{unknown}})(d_{\text{water}} / W_{\text{water}}) = (0.33 \text{ N})((1.00 \text{ g/mL}) / (0.25 \text{ N})) = 1.3 \text{ g/mL}$
- Look at the table
  - 1.32 g/mL is closest to light corn syrup

### Station 4

- Use ratios. Use a periodic table for molar masses of gases.
  - $P_{\text{argon}} / MM_{\text{argon}} \text{ [or]} P_{\text{neon}} / MM_{\text{neon}} = P_{\text{unknown}} / MM_{\text{unknown}} \rightarrow MM_{\text{unknown}} = P_{\text{unknown}} / (P_{\text{argon}} / MM_{\text{argon}}) \text{ [or]} P_{\text{unknown}} / (P_{\text{neon}} / MM_{\text{neon}}) = (1.77 \text{ atm}) / ((2.53 \text{ atm}) / (39.948 \text{ g/mol})) \text{ [or]} (1.77 \text{ atm}) / ((1.28 \text{ atm}) / (20.180 \text{ g/mol})) \approx 28 \text{ g/mol}$
  - Find gases with a molar mass close to 28 g/mol
    - Examples: CO (28.010 g/mol), ethene/ethylene (28.054 g/mol), N<sub>2</sub> (28.014 g/mol)
- Equal grams means rank by molar mass. The higher the molar mass, the smaller number of moles (and molecules) there will be with equal grams. For example, 10. g of Argon gas would yield 0.25 moles of Argon while 10. g of Neon gas would yield 0.50 moles of Neon.  $A < C < B$
- Since equal moles means equal molecules of each gas and the volume of each container is equal, the number density will be the same for all three containers.