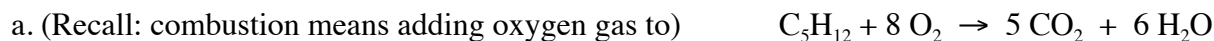


ASSIGNMENT SHEET #4 PART I APQ ANSWERS

5



b. $2.50 \text{ g } C_5H_{12} \div 72.15 \text{ g/mole } C_5H_{12} = 0.035 \text{ mole } C_5H_{12}$

$$0.035 \text{ mole } C_5H_{12} \times \frac{5 \text{ mole } CO_2}{1 \text{ mole } C_5H_{12}} = 0.173 \text{ moles } CO_2$$

$$\text{Using } PV = nRT, V = \frac{nRT}{P} = \frac{(0.173 \text{ mole})(0.0821)(25 + 273K)}{\frac{785 \text{ mmHg}}{760 \text{ mmHg/atm}}} = 4.10 \text{ L}$$

c. $5.00 \text{ g } C_5H_{12} \div 72.15 \text{ g/mole } C_5H_{12} = 0.070 \text{ mole } C_5H_{12}$

Then use a ratio: $\frac{243 \text{ kJ}}{0.07 \text{ mole}} = \frac{? \text{ kJ}}{1 \text{ mole}} \quad ? = 3,471 \text{ kJ/mole} \quad \therefore \Delta H = - 3471 \text{ kJ/mol}$

d. (Recall: effusion is diffusion through a porous partition; use Graham's law)

$$\text{rate}_{\text{unknown gas}} = 2 (\text{rate}_{\text{pentane}})$$

$$\frac{\text{rate}_{\text{unknown gas}}}{\text{rate}_{\text{pentane}}} = \sqrt{\frac{MM_{\text{pentane}}}{MM_{\text{unknown gas}}}} \quad \text{therefore, } 2 = \sqrt{\frac{72.15 \text{ g}}{X \text{ g}}} \quad X = 18 \text{ g/mole}$$

(Note: the unknown gas could be water!)

26

a. $PV = \frac{\text{mass}_{\text{gas}}}{MM_{\text{gas}}} RT \quad P_{\text{gas}} = P_{\text{atm}} - P_{\text{water}}$ (water vapor pressure, WVP)

b. Mass of gas container before allowing some gas to leave as well as the mass afterwards.
Read a thermometer and a barometer. Find the WVP at the given temperature. The volume of gas.

c. Equalizing the water levels inside and outside enables you to determine the pressure of the gas inside of the gas collection tube. At that point, the pressures inside and outside are the same.

d. $\frac{|64 \text{ g} - 58 \text{ g}|}{58 \text{ g}} \times 100 = \text{percent error}$

e. If pressure is not corrected for WVP, the P value will be too large. Solving for molar mass, MM, using the equation $PV = \frac{\text{mass}}{MM} RT$, you get $MM = \frac{(\text{mass})(R)(T)}{PV}$. The larger value for P will give you a smaller value for MM.

46

- a. Each of the balloons contains the same number of moles of gas (according to Avogadro's law). Therefore, the balloon with the highest mass of gas contains the gas with the highest molar mass, which is carbon dioxide (44 g/mole).
- b. Since all of the balloons are at the same temperature, and since temperature is a measure of average kinetic energy, the gases in each of the balloons have the same average kinetic energies.
- c. Carbon dioxide gas would deviate the most from ideal gas behavior. It has the greatest relative molar mass, meaning it has the greatest volume. All of the gases are nonpolar compounds, which means they only exhibit dispersion forces as IMFs. The strength of dispersion forces is dependent on the size of the compound; hence CO₂'s largest molar mass also gives it the strongest dispersion forces.
- d. Since average KE = $\frac{1}{2}$ mass x velocity², and since all of the gases have the same average KE (they are all at the same temperature), the gas with the lightest molar mass will have the greatest velocity, and will thus escape the fastest through the pores of the balloon. Therefore, the He balloon will shrink the most.

51

a. (Recall: combustion is the addition of oxygen gas) $C_3H_8 + 5 O_2 \rightarrow 3 CO_2 + 4 H_2O$

b. $10.0 \text{ g } C_3H_8 \div 44 \text{ g/mole } C_3H_8 = 0.227 \text{ mole } C_3H_8$

$$0.227 \text{ mole } C_3H_8 \times \frac{5 \text{ mole } O_2}{1 \text{ mole } C_3H_8} = 1.14 \text{ mole } O_2 \text{ needed to completely combust}$$

$$\text{Using } PV = nRT, V = \frac{(1.14 \text{ mole})(0.0821)(30 + 273K)}{1 \text{ atm}} = 28.27 \text{ L of } O_2 \text{ needed}$$

$$28.27 \text{ L } O_2 \times \frac{100L_{air}}{21L_{O_2}} = 134.6 \text{ L air needed}$$

52

a. Using $PV = \frac{mass}{MM} RT$, mass CO₂ produced = $\frac{(MM)(P)(V)}{RT}$

$$\text{Mass } CO_2 = \frac{(44 \text{ g/mole})\left(\frac{750 \text{ mmHg}}{760 \text{ mmHg/atm}}\right)\left(\frac{75 \text{ mL}}{1000 \text{ mL/L}}\right)}{(0.0821)(20 + 273K)} = 0.1354 \text{ g}$$

68

a. $P_{\text{hydrogen gas}} = P_{\text{atm}} - P_{\text{water}} = 745 \text{ mmHg} - 23.8 \text{ mmHg} = 721.2 \text{ mmHg} \div 760 \text{ mmHg/atm} = 0.949 \text{ atm}$

Using $PV = nRT$, $n_{\text{hydrogen}} = \frac{P_{\text{hydrogen}} V}{RT} = \frac{(0.949 \text{ atm})(\frac{90 \text{ mL}}{1000 \text{ mL/L}})}{(0.0821)(25 + 273 \text{ K})} = 0.00349 \text{ moles H}_2$

b. Using $PV = nRT$, $n_{\text{total gas}} = \frac{P_{\text{atm}} V}{RT} = \frac{(\frac{745 \text{ mmHg}}{760 \text{ mmHg/atm}})(0.09 \text{ L})}{(0.0821)(298 \text{ K})} = 0.003606 \text{ moles gas}$

moles $\text{H}_2\text{O} = \text{moles of total gas} - \text{moles of H}_2 \text{ gas} = 0.003606 \text{ mole} - 0.00349 \text{ mole} = 0.000116 \text{ mole}$

$0.000116 \text{ mole H}_2\text{O} \times 6.02 \times 10^{23} \text{ molecules/mole} = 6.98 \times 10^{19} \text{ water vapor molecules}$

c. Using Graham's Law: $\frac{\text{rate}_{\text{hydrogen}}}{\text{rate}_{\text{water}}} = \sqrt{\frac{MM_{\text{water}}}{MM_{\text{hydrogen}}}} = \sqrt{\frac{18 \text{ g/mole}}{2 \text{ g/mole}}} = 3$

Therefore, the hydrogen molecules are moving 3 times as fast as the water molecules.

d. Water deviates more from ideal gas behavior than hydrogen because H_2O has stronger IMFs due to its polar nature and it has a larger volume due to its larger molar mass.

401

a. Gas behavior deviates from ideality at low temperatures and/or under high pressures. At low temps, the gas particles move more slowly, allowing intermolecular forces (IMFs) to become significant factors in particle motion. Under high pressures, the volumes of the individual particles become significant – gases can't be compressed into nothing. Under extremes of both situations, the gases tend to liquefy or deposit (solidify).

b. Sulfur dioxide will deviate the most due to its polar nature – allowing for more IMFs to come into play – and due to its relatively large molar mass, which means it has the largest volume.

c. Under low pressure, the space between the gas particles in a gas sample is so large that the volumes of the individual particles are of no consequence. At high temperatures, the speed of the particles is so great that no IMFs can possibly influence the motion of the individual particles.

402

The a value is determined by the gas particle's polarity and the b value is determined by the gas particle's molar mass, which is proportional to its volume. H_2S has the higher a value and b value due to its relative polarity and molar mass, respectively, compared to H_2 .

403

$$PV = \frac{\text{mass}}{MM} RT = (750 \text{ mmHg})(1 \text{ L}) = \frac{3.53 \text{ g}}{MM} (62.4 \frac{\text{mmHg} \cdot \text{L}}{\text{mole} \cdot \text{K}})(27 + 273) \quad MM = 88.1 \text{ g/mol}$$

That's All For Now, folks!

ASSIGNMENT SHEET #4 PART II APQ ANSWERS

2d

The boiling point of chlorine is lower than that of bromine because of chlorine's relatively smaller mass and size. While both molecules are non-polar and have only dispersion forces as IMFs, the larger bromine molecule dispersion forces are of greater strength than those of the chlorine molecules. Hence, bromine molecules require more energy to overcome the IMFs.

16

- The polar NH_3 molecules have hydrogen bonding as their principle IMF, which is an appreciably stronger IMF than the dispersion forces of the non-polar CH_4 molecules.
- Both ethane and hexane are non-polar molecules, which means that they each have dispersion forces as their IMFs. Dispersion forces are greater in molecules with greater volume and mass, so they are stronger in hexane than in ethane. Hence, hexane is held together in the liquid state at room temperature, whereas ethane can overcome the IMFs at room temperature and become gaseous.
- Silicon can form network covalent bonds, which are much stronger than the dispersion forces that hold chlorine molecules together.
- The charge densities of the ions in MgO (+2 and -2 ions) are much stronger than the charge densities of the ions in NaF (+1 and -1 ions). This creates stronger electrostatic forces between the ions in MgO , which results in a higher melting point.

38a

Water boils when its vapor pressure equals atmospheric pressure. The atmospheric pressure is higher at sea level than at high altitude, so the water must get hotter at sea level in order to boil. Therefore, at high altitude, the water boils at a lower, temperature, requiring a longer cooking time.

50a

HF molecules can form hydrogen bonds with one another; HCl molecules are held together with dipole-dipole forces. The H-bonds are stronger than the dipole-dipole forces, so the HF is a liquid whereas the HCl is a gas at the same temperature.

60

- Point V represents the triple point. At the triple point of any substance, all three phases of matter – solid, liquid, gas – exist in equilibrium with one another.
- Every point on the curve between V and W represents an equilibrium condition between the liquid and gaseous states; i.e., evaporation and condensation are occurring at the same rate.
- The material goes from a solid (X) to the sublimation point (Y), where the material sublimates and deposits at the same rate, then becomes a gas (Z).
- The solid will sink in the liquid. From the phase diagram, at a constant temperature, as you increase the external pressure on the surface of the material, which makes the material more dense, the material remains in the solid state or changes from a liquid to a solid. This indicates that the solid is more dense than the liquid. The slope of the solid-liquid line is positive, which means that as you increase the external pressure, you raise the freezing point (temperature); i.e., making it "easier" to freeze the material – you don't have to remove as much energy to allow the IMFs to solidify the material. This is only true for substances whose solid states are denser than their liquid states.

65bc

b. Being a more polar molecule, H_2O molecules form stronger hydrogen bonds than the less polar NH_3 molecules. The two lone pairs on each of the oxygen atoms are more negative than the single lone pair on each of the nitrogen atoms. Therefore, the hydrogen atoms are more strongly attracted to the lone pairs in water than those in ammonia.

c. In each material, the carbon atoms are network covalently bound. However, in diamond, the network covalent bonding is 3-dimensional, whereas in graphite, the network covalent bonding is 2-dimensional. Weak dispersion forces loosely hold the 2-dimensional sheets of graphite atoms together. As such, the sheets shear from one another easily, and the sheets act as lubricants. Diamond does not shear apart, and hence cannot be used as a lubricant.

67b

As the air pressure decreases in the bell jar, the boiling point will eventually be reached at the lower room temperature. You will see the water boil. Over time, the beaker will be completely empty as the pump removes the water vapor.

404

a. The metallic bonding of potassium allows for current conduction. The "sea of valence electrons" is quite mobile and delocalized in terms of nuclear control. In the ionic bonds found in solid potassium nitrate, the electrons are very localized – they are tightly held by each ion. As such, there are no mobile electrons. Hence, the KNO_3 is not a conductor of current.

b. The non-polar carbon tetrachloride molecule is smaller in mass, and hence in volume, than the non-polar carbon tetrabromide molecule. CCl_4 's dispersion forces are therefore weaker than CBr_4 's, which explains its lower relative boiling point.

c. (You saw this Q in 50 a; the AP folks like this question!) HF has a stronger dipole moment than HCl due to the greater difference in electronegativity in HF relative to that in HCl. HF molecules can form hydrogen bonds that are stronger than the dipole-dipole forces found in HCl. These stronger IMFs hold HF in the liquid state and give HF a higher boiling point.

d. Butane is more non-polar than chloroethane. Therefore, butane has only relatively weak dispersion forces keeping it together whereas chloroethane and relatively strong dipole-dipole forces holding it together.