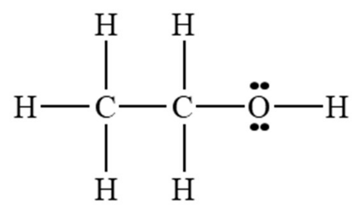
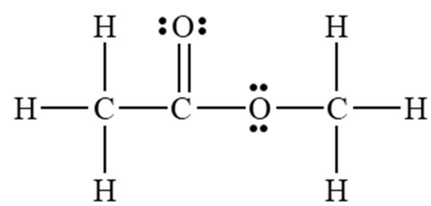
Unit 3 Summative Assessment Practice

Show your work for each question in the space provided. Examples and equations may be included in your responses where appropriate. For calculations, clearly show the method used and the steps involved in arriving at your answers. You must show your work to receive credit for your answer. Pay attention to significant figures.

Substance	Formula	Structural Formula	Boiling Point (K)	Vapor Pressure at 293 K (torr)
ethanol	C_2H_6O		351	45
methyl acetate	$C_3H_6O_2$		330	?

1. Answer the following questions related to the substances shown in the table above.

(a) Do you predict that the vapor pressure of methyl acetate at 293 K is less than 45 torr or greater than 45 torr? Justify your answer in terms of the data in the table above.

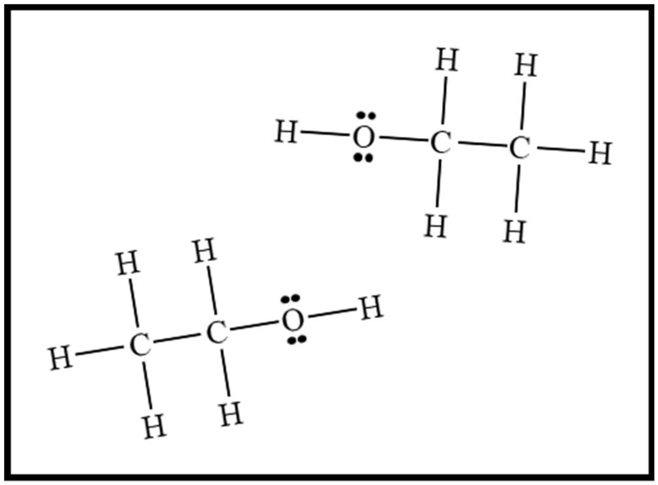
(b) Identify all types of intermolecular forces present in each substance.

ethanol ____

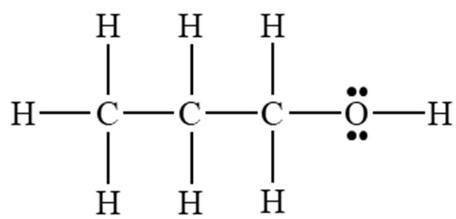
methyl acetate ______________________________________

(c) Explain the difference in boiling point for these two substances in terms of the intermolecular forces identified in part (b).

1. (continued)



(d) Draw a single dashed line (------------) in the diagram above to represent the strongest type of intermolecular attractive force experienced between two ethanol molecules.



(e) The structural formula of 1-propanol is shown above.

(i) Identify the specific type of intermolecular force that is most responsible for explaining why 1-propanol (BP = 370 K) has a higher boiling point than ethanol (BP = 351 K). Answer by drawing a circle around one of the choices below.

London dispersion forces   dipole-dipole forces   hydrogen bonding

(ii) Justify your choice in part (e)(i).

Substance	Radius (pm)
Mg^{2+}	86
Ca^{2+}	114

2. Answer the following questions related to the substances shown in the table above.

   (a) Identify the type of interparticle attractive force that is formed between one of the substances in the table above and a sample of H_2O molecules.

   (b) Which substance, Mg^{2+} or Ca^{2+}, will experience stronger attractions to the nearby H_2O molecules in aqueous solution? Justify your answer in terms of Coulomb's law.

Substance	#1	#2	#3	#4
Melting Point (K)	3246	1941	987	178
Electrical Conductivity In Solid Phase	None	High	None	None
Electrical Conductivity In Liquid Phase	None	High	High	None

3. Each substance listed in the table above is classified as a different type of solid (e.g., metallic, ionic, covalent network, and molecular).

   Based on the information in the table above, identify the type of solid for each substance.

   #1 ______________________________ #3 ______________________________

   #2 ______________________________ #4 ______________________________

4. A balloon contains a pure sample of He(*g*) and has a volume of 10.0 L, a temperature of 25.0°C, and a pressure of 755 torr.

(a) Calculate the mass of He(*g*) present in the balloon.

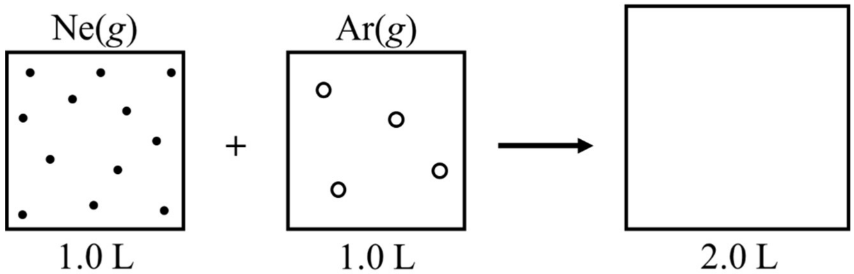
(b) The balloon rises to a higher altitude. The new conditions are a temperature of –50.0°C and a pressure of 0.475 atm. Calculate the new volume of the balloon in units of liters. Assume that no He(*g*) escapes from the balloon.

Sample	Amount of Gas (mol)	Volume (L)	Temperature (K)	Observed Pressure (atm)
#1	0.500	10.0	500.	2.05
#2	10.0	1.0	500.	418

5. Data for two different samples of Xe(*g*) are shown in the table above.

(a) Which sample, #1 or #2, shows an observed pressure value that is different from the value predicted by the ideal gas law? Justify your answer with a calculation.

(b) Use particle-level reasoning to explain why the gas sample you chose in part (a) has an observed pressure value that is a deviation from ideal gas behavior.



6. The particle diagrams shown above represent two sealed 1.0 L vessels, each containing a pure sample of gas at the same temperature. The pressure of Ne(*g*) in the vessel on the left is 1.74 atm. Use the information in the particle diagrams, principles of kinetic molecular theory, and the relationships between variables in the ideal gas law to answer the following questions.

(a) Calculate the pressure of Ar(*g*) in the sealed 1.0 L vessel.

(b) Indicate whether the average kinetic energy of the Ne(*g*) particles is less than, equal to, or greater than the average kinetic energy of the Ar(*g*) particles. Justify your answer.

(c) Indicate whether the average speed of the Ne(*g*) particles is less than, equal to, or greater than the average speed of the Ar(*g*) particles. Justify your answer.

(d) The samples of Ne(*g*) and Ar(*g*) are completely transferred from their original containers and combined together in a previously evacuated 2.0 L vessel. Calculate the total pressure of the gas mixture in the 2.0 L vessel. Assume that the temperature remains constant.

7. Brass is a mixture containing Cu(*s*) and Zn(*s*). A student dissolves a brass sample in an excess amount of HNO_3(*aq*). This solution is then diluted with distilled water so that the final volume of the solution is equal to 100.0 mL. Assume that all of the atoms of Cu and Zn in the brass sample are converted into Cu^{2+}(*aq*) ions and Zn^{2+}(*aq*) ions. Data from the experiment is shown in the table below.

Mass of brass sample	Final Volume of Solution Containing Cu^{2+}(*aq*) and Zn^{2+}(*aq*)
3.8 g	100.0 mL

The student prepares a stock solution of 0.500 *M* $Cu(NO_3)_2$(*aq*) by dissolving solid copper(II) nitrate trihydrate in water. Information about the solid solute is shown below.

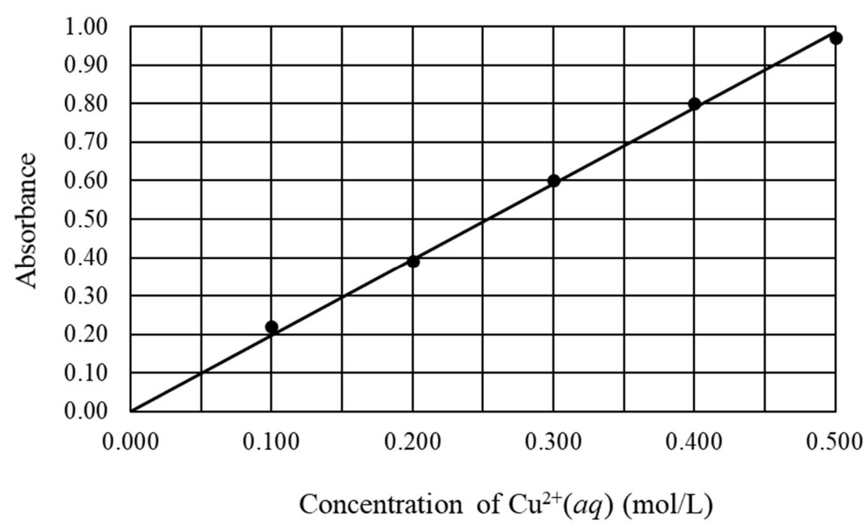
Chemical Name	Chemical Formula	Molar Mass (g/mol)	Appearance
copper(II) nitrate trihydrate	$Cu(NO_3)_2•3H_2O$	241.618	blue crystals

(a) Calculate the mass, in grams, of solid $Cu(NO_3)_2•3H_2O$ that is required to prepare 200.0 mL of 0.500 *M* $Cu(NO_3)_2$(*aq*).

The stock solution of 0.500 *M* $Cu(NO_3)_2$(*aq*) is used to prepare four different solutions with the following concentrations: 0.100 *M*, 0.200 *M*, 0.300 *M*, and 0.400 *M*.

(b) Calculate the volume of 0.500 *M* $Cu(NO_3)_2$(*aq*) that is required to prepare 50.0 mL of 0.400 *M* $Cu(NO_3)_2$(*aq*).

The absorbance of each solution of $Cu(NO_3)_2$(*aq*) is measured with a spectrophotometer that is set at a wavelength of optimum absorbance for Cu^{2+}(*aq*) ions. The data are used to create the following graph.



7. (continued)

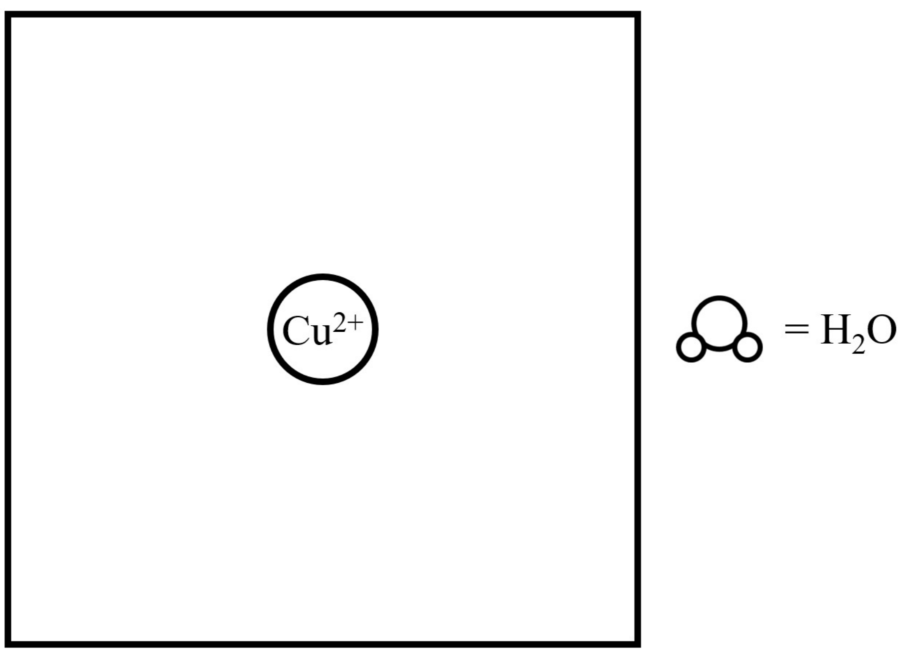
The spectrophotometer is also used to measure the absorbance of the brass solution containing Cu^{2+}(*aq*) and Zn^{2+}(*aq*) that had been prepared earlier. Assume that the Zn^{2+}(*aq*) ions in the solution have an absorbance value of zero.

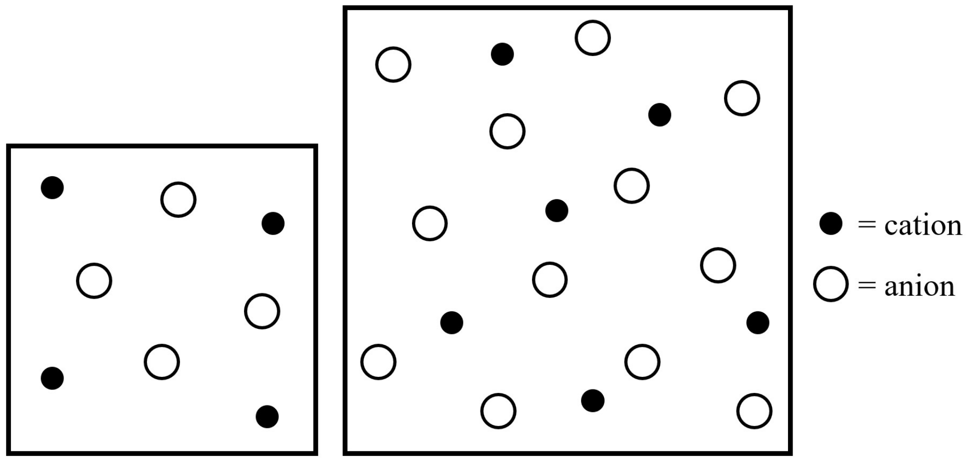
(c) The absorbance of the brass solution is recorded as 0.75. Use the graph on the previous page to estimate the concentration of Cu^{2+}(*aq*) in the brass solution. Express your answer to two decimal places.

(d) Calculate the number of moles of Cu^{2+}(*aq*) ions present in the 100.0 mL sample of the brass solution.

(e) Calculate the mass percent of Cu in the 3.8-gram sample of brass.

(f) In the box below, complete the particle-level diagram to represent the attractions between the Cu^{2+} ion and the surrounding water molecules in an aqueous solution. In your drawing, the Cu^{2+} ion should be surrounded by three water molecules with the proper orientation, based on the charge of the ion and the direction of the dipole in the water molecule. Represent each water molecule as shown below.



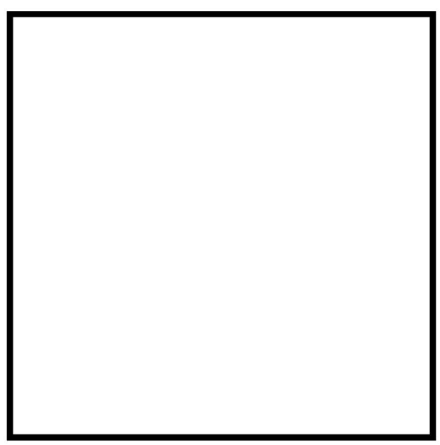


1.0 L of 1.0 M NaCl(aq)   3.0 L of $MgCl_2$(aq)

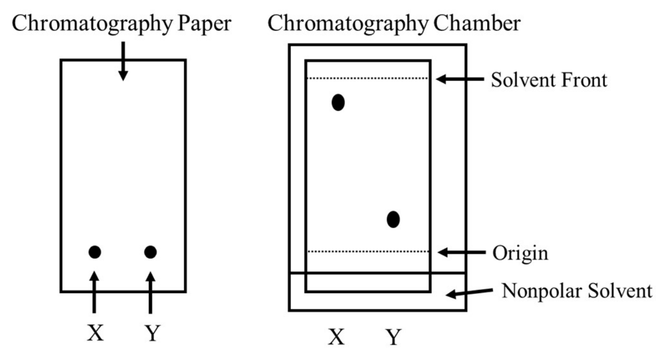
8. Two particle diagrams are shown above. The diagram on the left represents 1.0 L of 1.0 M NaCl(aq), and the diagram on the right represents 3.0 L of $MgCl_2$(aq). Water molecules are not shown. Use the information in these particle diagrams to answer the following questions.

   (a) Determine the concentration, in mol/L, of $MgCl_2$ in the 3.0 L container represented by the diagram on the right. ______________________________

   (b) In the space below, draw a particle diagram to represent 1.0 L of 1.5 M NaCl(aq).



1.0 L of 1.5 M NaCl(aq)

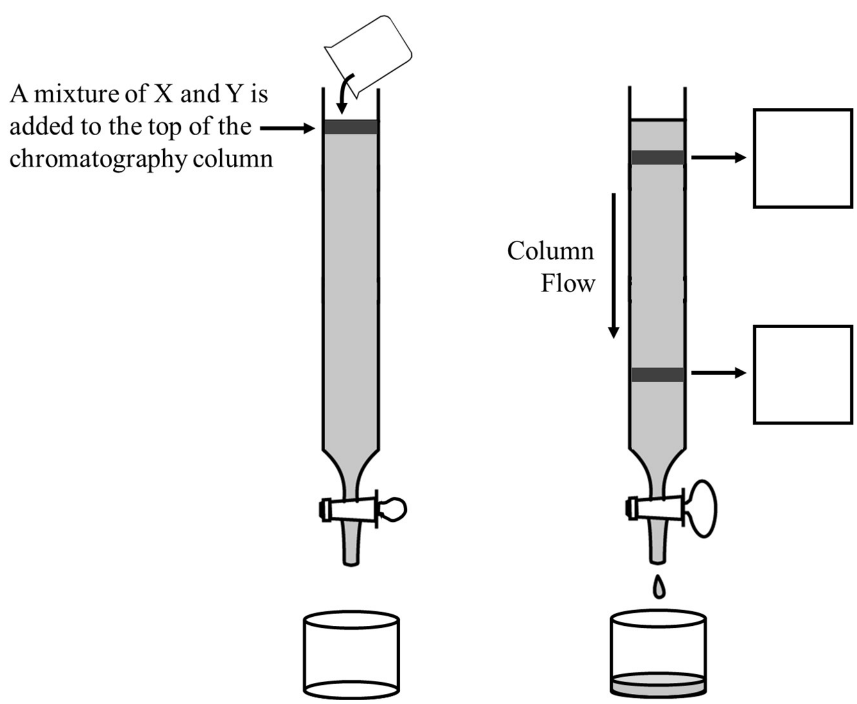


9. A paper chromatography experiment is performed to investigate the properties of two different pure dyes, labeled as X and Y. The student places a drop of each dye at the indicated position on the chromatography paper (a polar material) as shown above on the left. The paper is placed in a nonpolar solvent, which travels up the paper. The results of the experiment are shown above on the right.

(a) Which dye (X or Y) represents the more polar substance? Justify your answer in terms of the interactions between the dye and the mobile phase in this experiment.

A second chromatography experiment is performed in which a mixture of X and Y is carefully added to the top of a chromatography column filled with the same nonpolar solvent used in the paper chromatography experiment. Separation of the mixture occurs as the dyes travel at different rates through the column. Two distinct bands are observed as shown below in the diagram on the right.

(b) Based on the results of the paper chromatography experiment described above, Identify each component of the mixture by writing the letter "X" or "Y" in each box provided in the diagram below.



10. Infrared spectroscopy is a useful tool for scientists who want to investigate the structure of certain molecules. Which of the following types of transitions is most likely to occur as the result of a molecule absorbing a photon of infrared radiation?

___________ A transition in molecular rotational levels

___________ A transition in molecular vibrational levels

___________ A transition in electronic energy levels

11. The Br–Br bond has a bond energy of 193 kJ mol^{-1}.

(a) Calculate the minimum amount of energy, in joules, that is required to break the Br–Br bond in a Br_2 molecule.

(b) Calculate the longest wavelength of light, in meters, that can supply enough energy per photon to break the Br–Br bond in a Br_2 molecule.

(c) Does a photon with a frequency of 4.00×10^{14} s^{-1} have enough energy to break the Br–Br bond? Support your answer with a calculation.