Review: Phases and Solutions

Name: _____
Period: ____

(1) Use principles of atomic structure, bonding, and/or intermolecular forces to explain each of the following. The response must included specific information about all substances referred to in each question.

(a) At a pressure of 1 atm, the boiling point of NH_3 (l) is 240 K, whereas the boiling point of NF_3 (l) is 134 K.

(b) The melting point of KCl (s) is 776 ºC, whereas the melting point of NaCl (s) is 801 ºC.

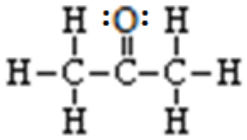
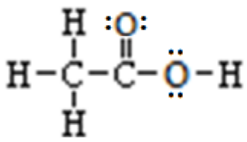
(c) The boiling point of Cl_2 is –34 ºC, whereas the boiling point of Br_2 is 56 ºC.

(d) The melting point of MgO is 2852 ºC, whereas the melting point of NaF is 993 ºC.

(e) The melting point of SiO_2 is 1600 ºC, whereas the melting point of CO_2 is –78.5 ºC.

(f) An alloy of copper (atomic radius 128 pm) and gold (atomic radius 174 pm) is hard and strong while an alloy of silver (atomic radius 172 pm) and gold is ductile and malleable.

(2) Consider the liquids acetone and acetic acid. The Lewis structure for each compound is given below.

Molecule	Acetone	Acetic Acid
Lewis Structure		
Intermolecular Forces		
Boiling Point	56 ºC	118 ºC
Vapour Pressure (at 25 ºC)	250 mm Hg	15 mm Hg

(a) Identify the type of organic compound represented by each molecule.

(b) List the types of intermolecular forces present for each molecule in the above table.

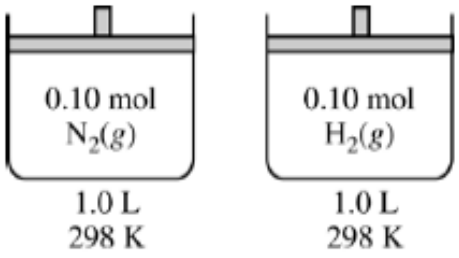
(c) (i) Why does acetic acid have a higher boiling point than acetone?

(ii) A solution contains a mixture of acetone and acetic acid. What experimental technique could be used to separate the components of this mixture?

(d) Why does acetone have a higher vapour pressure than acetic acid?

(e) Concentrated acetic acid is available as a 15 M solution. Describe how to prepare 100 mL of 3.0 M acetic acid solution.

(3) Consider the two containers of volume 1.0 L at 298 K as shown below. One container holds 0.10 mol N_2 (g) and the other holds 0.10 mol H_2 (g). The average kinetic energy of a molecule of N_2 (g) is 6.2×10^{-21} J. Assume that both gases behave ideally.



(a) Is the pressure in the container holding H_2 (g) greater than, less than, or equal to the pressure in the container holding N_2 (g)? Explain.

(b) What is the average kinetic energy of a molecule of H_2 (g)?

(c) The molecules of which gas, N_2 or H_2, have the greater average speed. Explain.

(d) What change could be made that would decrease the average kinetic energy of the N_2 molecules in the container?

(e) If the volume of the container holding the H_2 was decreased to 0.50 L at 298 K, what would be the effect on the pressure within the container?

(f) Under identical conditions, a sample of nitrogen effuse at twice the rate that a sample of unknown gas effuses. Calculate the molar mass of the unknown gas.

(4) A 0.535 g sample of ammonium chloride is reacted with 25.0 mL of 0.500 M sodium hydroxide solution. The ammonia gas produced in the reaction is collected over water at 25 ºC. The total pressure of the mixture is 780.0 torr and the vapour pressure of water (at 25 ºC) is 23.8 torr.
(a) Write a balanced chemical equation for the reaction.

(b) Calculate the moles of ammonia produced in the reaction.

_____

(c) Determine the volume of ammonia gas produced in the experiment (in mL).

_____ mL

Answers:

(1) (a) The intermolecular forces for NH_3 are stronger than for NF_3, since NH_3 can form hydrogen bonds (the strongest intermolecular force) and NF_3 only has dipole interactions (a weaker intermolecular force). As a result, the boiling point for NH_3 is higher than for NF_3.

(b) Both KCl and NaCl have ionic bonds. The sodium ion is smaller than the potassium ion. Since sodium is smaller, the electrostatic attraction between the ions in NaCl is stronger than between the ions in KCl so NaCl has a larger lattice energy and higher melting point than KCl.

(c) Both Cl_2 and Br_2 are non-polar so the only type of intermolecular bond for each is London dispersion forces. Since Br_2 is a larger molecule has more electrons than Cl_2, the electrostatic force of attraction/ London dispersion forces for Br_2 are stronger than for Cl_2, and Br_2 has a higher boiling point than Cl_2.

(d) Both MgO and NaF have ionic bonds. In the compound MgO, the ions each have a charge of two compared to the compound NaF in which the ions each have a charge of one. The higher the charge, the stronger the force of electrostatic attraction between ions and the larger the lattice energy and higher the melting point of the compound. Since MgO has the larger lattice energy, it has a higher melting point than NaF.

(e) SiO_2 is a network solid and CO_2 is a molecular solid. Since SiO_2 is a network solid, melting requires breaking strong covalent bonds and requires more energy/a higher temperature. Since CO_2 is a molecular solid, melting only requires breaking intermolecular forces and requires less energy/a lower temperature.

(f) The alloy of copper and gold is an interstitial alloy (since the atoms differ significantly in size) and is therefore hard and strong. The alloy of silver and gold is a substitutional alloy (since the atoms are of comparable size) and is therefore ductile and malleable.

(2) acetone: ketone

acetic acid: carboxylic acid

(b) acetone: London dispersion forces, dipole interactions

acetic acid: London dispersion forces, dipole interactions, hydrogen bonds

(c) (i) The intermolecular forces for acetic acid are stronger than for acetone, since acetic acid can form hydrogen bonds (the strongest intermolecular force) and acetic acid only has dipole interactions (a weaker intermolecular force). As a result, the boiling point for acetic acid is higher than for acetone.

(ii) Distillation (separates the components of a solution based on their differing boiling points)

(d) Acetone has weaker intermolecular forces than acetic acid and therefore acetone will more readily evaporate and produce more vapour/a higher vapour pressure than acetic acid.

(e) Measure ~50 mL of water into a 100 mL volumetric flask. Using a buret, measure 20.0 mL of 15 M acetic acid. Add slowly to the water. Add water to the volumetric flask to a total volume of 100 mL.

(3) (a) Both containers have the same number of moles, volume, and temperature, therefore the pressures will be equal. ($P = nRT/V$)

(b) Both gases are at the same temperature, therefore they will have the same kinetic energy. The kinetic energy of the H_2 molecules will be equal to 6.2×10^{-21} J.

(c) Both gases have the same kinetic energy, but the H_2 molecules have a smaller molar mass than the N_2 molecules, therefore the H_2 molecules will have a higher speed than the N_2 molecules.

(d) The kinetic energy of a gas depends on the temperature of the gas. In order to decrease the kinetic energy of the N_2 molecules, the temperature of the N_2 could be lowered.

(e) Since the volume halved, the pressure will be doubled.

(f) 112 g/mol

(4) (a) $NH_4Cl + NaOH \rightarrow NH_3 + H_2O + NaCl$

(b) 0.0100 mol NH_3

(c) 246 mL NH_3