CHEMISTRY 202
Hour Exam I
September 26, 2024
Dr. D. DeCoste

Name _____

Signature _____

T.A. _____

This exam contains 20 questions on 4 numbered pages. Check now to make sure you have a complete exam. Determine the **best** answer to these questions and enter these on the special answer sheet. Also, **circle your responses** in this exam booklet.

Each multiple-choice question is worth the same amount.

Useful Information:
Always assume ideal behavior for gases (unless explicitly told otherwise).

$PV = nRT$

$R = 0.08206$ Latm/molK $= 8.3145$ J/Kmol

$K = °C + 273$

$N_A = 6.022 \times 10^{23}$

$\upsilon_{rms} = \sqrt{\frac{3RT}{M}}$

$\lambda = \frac{1}{\sqrt{2}(N/V)(\pi d^2)}$

$Z_A = A\frac{N}{V}\sqrt{\frac{RT}{2\pi M}}$

$Z = 4\frac{N}{V}d^2\sqrt{\frac{\pi RT}{M}}$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

Solubility Rules:
1. Most nitrate salts are soluble.
2. Most salts of sodium, potassium, and ammonium cations are soluble.
3. Most chloride salts are soluble. Exceptions: silver, lead(II), and mercury(I) chloride.
4. Most sulfate salts are soluble. Exceptions: calcium, barium, and lead(II) sulfate.
5. Most hydroxide salts can be considered insoluble. Soluble ones: sodium, potassium, and calcium hydroxide.
6. Consider sulfide, carbonate, and phosphate salts to be insoluble.

1. Consider ionic compounds made of nitrate ions and the following metal ions: sodium (Na), aluminum (Al), potassium (K), calcium (Ca), and barium (Ba). Rank the compounds from **highest to lowest percent by mass nitrogen** and choose the compound that is **third** in the ranking.

   a) sodium nitrate
   b) aluminum nitrate
   c) potassium nitrate
   d) calcium nitrate
   e) barium nitrate

2. The term "vitamin D" refers to a group of fat-soluble vitamins, one of which is vitamin D_2. Vitamin D_2 has the chemical formula C_xH_yO, a molar mass of 396.63 g/mol, and is 84.78% carbon by mass. Determine the value for *y* in the chemical formula.

   a) 15 b) 28 c) 44 d) 60 e) More data needed.

3. A 55.85-g bar of iron (Fe) bar is placed in a container with oxygen gas and allowed to react with the oxygen gas to form iron(II) oxide. The mass of solid in the container after the reaction is complete is 67.85 g. Which of the following is true?

   a) The iron was the limiting reactant and 12.00 g of oxygen is left over.
   b) The iron was the limiting reactant and 20.00 g of oxygen is left over.
   c) The oxygen was the limiting reactant and 53.89 g of iron(II) oxide was produced.
   d) The oxygen was the limiting reactant and 16.00 g of oxygen was originally present.
   e) Neither reactant was limiting.

4. Ammonia (NH_3) reacts with oxygen gas to produce a "nitrogen oxide" and water. When 100.0 g of ammonia is reacted with an excess of oxygen gas, you find that 158.6 g of water is produced. Which of the following is the "nitrogen oxide" produced?

   a) Nitrogen monoxide
   b) Dinitrogen monoxide
   c) Nitrogen dioxide
   d) Dinitrogen tetroxide
   e) With the given data, any of the above (a-d) could be the "nitrogen oxide."

5. Consider the reaction of nitrogen gas reacting with hydrogen gas to form ammonia (NH_3). Suppose you react 10.00 g of nitrogen gas with hydrogen gas. What mass of hydrogen gas must you use so that you end up with the same mass of ammonia and hydrogen gas after the reaction is complete?

   a) 2.16 g b) 10.00 g c) 12.16 g d) 14.32 g e) 16.28 g

6. What is the **minimum** mass of solid calcium chloride required to add to 100.0 mL of a 0.100 *M* aqueous solution of silver nitrate to result in the maximum possible amount of precipitate formation?

   a) 0.378 g b) 0.555 g c) 0.755 g d) 1.11 g e) 2.22 g

7. How many of the following will result in a 0.2500 *M* solution of NaCl(*aq*)?

- Add 2.265 g NaCl(*s*) to enough water to make 155.0 mL of solution.
- Add 240.0 mL of water to 150.0 mL of a 0.6500 *M* NaCl(*aq*) solution.
- Mix 50.00 mL of 0.5000 *M* NaCl(*aq*) solution with 100.0 mL of 0.125 *M* NaCl(*aq*) solution.
- Allow 60.00 mL of water to evaporate from 150.0 mL of a 0.1500 *M* solution of NaCl(*aq*).

a) 0 b) 1 c) 2 d) 3 e) 4

8. Vinegar is a 5.00% acetic acid solution. That is, 5.00% of the mass of the aqueous solution is acetic acid ($HC_2H_3O_2$). Suppose you leave a solution of vinegar open such that enough water evaporates so that the solution is 10.0% acetic acid by mass (assume that the acetic acid does not evaporate). What percentage of the water must have evaporated from the solution?

a) 45.0% b) 47.6% c) 50.0% d) 52.6% e) 55.0%

9. We all love the explosions in lecture from the mixture of hydrogen and oxygen gases. Suppose we have two samples of these mixtures, both at the same conditions of pressure and temperature. Mixture A is 50% hydrogen gas **by mass**, and mixture B is 50% hydrogen gas **by number of moles**. Determine the ratio of densities of mixture B compared to mixture A.

a) 0.223 b) 0.336 c) 1.00 d) 2.98 e) 4.48

10. At a certain temperature, methane gas (CH_4) reacts with oxygen gas to produce water vapor and carbon dioxide. Consider a mixture of methane gas and oxygen gas in a container fitted with a frictionless, massless piston. The reaction is initiated, and the reaction goes to completion at constant temperature. Which of the following is true about the density of the mixture after the reaction is complete compared to the initial density of the reaction mixture?

a) The density after the reaction is complete is greater than the initial density.
b) The density after the reaction is complete is equal to the initial density.
c) The density after the reaction is complete is less than the initial density.
d) The density changes if one of the reactants is limiting, but whether the density increases or decreases depends on which reactant is limiting.

11. Consider a mixture of **equal masses** of helium (He) gas and neon (Ne) gas in separate containers at the same pressure and temperature. Determine the ratio of:

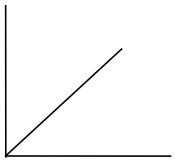
[collision frequency (Z_A) of He] : [collision frequency (Z_A) of Ne]
(for a given area, A, of the walls of each container)

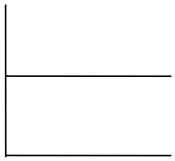
a) 0.4454 b) 1.000 c) 2.245 d) 5.041 e) 11.32

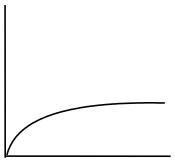
12. Suppose we had a sealed, flexible balloon filled with air in an atmosphere of helium. Approximately what temperature would we need to heat the air such that it would have the same density as helium at 25°C? Note: the "~" symbol means "about"

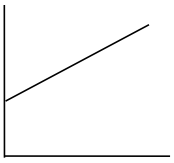
a) ~500K b) ~1000K c) ~2000K d) ~4000K e) ~10,000K

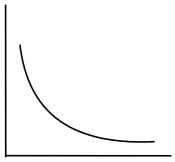
13-15. Indicate which of the graphs below best represents each plot described in questions 13, 14, and 15. Note: the graphs may be used once, more than once, or not at all.

a) 

b) 

c) 

d) 

e) 

13. Mean free path (λ) (y) vs. T (K) (x) for 1.0 mole of an ideal gas in a container fitted with a massless, frictionless piston.

14. PV (y) vs. V (x) for 1.0 mole of an ideal gas at constant temperature.

15. PV (y) vs. T (K) (x) for 1.0 mole of an ideal gas.

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16. Consider an equimolar (equal number of moles) mixture of H_2 and Cl_2 gases in a rigid steel container. The value of the equilibrium constant, *K*, for the reaction written below at a given temperature is equal to 1.00. Determine the percent of hydrogen gas that has reacted to produce HCl(*g*) at this temperature.

$$H_2(g) + Cl_2(g) \rightleftharpoons 2HCl(g)$$

a) 25.0% b) 33.3% c) 50.0% d) 66.7% e) 75.0%

17. At approximately which temperature, or temperature range, is the value of the equilibrium constant, *K*, essentially equal to the value of the equilibrium constant, K_p for any gaseous system?

a) About 12.2 K.
b) About 273 K
c) Above temperatures of 500. K
d) The values of *K* and K_p are always different for such a system.

18. Consider the following equilibrium system: $2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$.

At a certain temperature, $K_p = 3.014 \times 10^{-2}$. When an equimolar (equal number of moles) mixture of SO_2 and O_2 gases are reacted in a rigid steel container, equilibrium is reached after 25.00% of the oxygen gas has reacted. Calculate the **initial** pressure of O_2 gas.

a) 11.06 atm b) 22.12 atm c) 33.18 atm d) 44.24 atm e) 66.36 atm

19. How many of the following are **false** considering chemical equilibrium?

- Changing the pressure of a gaseous system at equilibrium must result in a shift in the equilibrium position.
- Adding an inert gas to a gaseous system at equilibrium can possibly change the equilibrium position at constant volume, but cannot do so at constant pressure.
- For a given reaction at a given temperature, there are more than one set of equilibrium conditions for the reactants and products.
- Chemical equilibrium is best considered to be a microscopically static process.

a) 0 b) 1 c) 2 d) 3 e) 4

20. Consider the reaction of hydrogen and oxygen gases to produce water vapor that we have done in lecture several times. Suppose we had a system with hydrogen and oxygen gases at equilibrium with water vapor. Which of the following best describes the effect that **raising the temperature** on such a system would have. Consider it written as:

$$2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$$

a) Equilibrium shifts, but the value of *K* stays constant.
b) Equilibrium shifts to the right and the value of *K* increases.
c) Equilibrium shifts to the right and the value of *K* decreases.
d) Equilibrium shifts to the left and the value of *K* increases.
e) Equilibrium shifts to the left and the value of *K* decreases.