KEEP THIS SECTION!!!!!!!!!

CHEMISTRY 202
Hour Exam I (Multiple Choice Section)
September 26, 2019
Dr. D. DeCoste

Name ______________________________

Signature ____________________________

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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 3 points (total of 60 points).

The free response section is worth a total of 60 points.

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. A compound consisting of element "X" and hydrogen is 8.7% hydrogen by mass. The formula of the compound is X_3H_8. Determine the identity of element "X".

   a) Li b) B c) C d) Fe e) Si

2. Which of the following compounds has a percent mass of hydrogen closest to half (½) of the value of the percent mass of hydrogen in water?

   a) HF b) CH_4 c) HCl d) NH_3 e) LiH

3. Consider that calcium metal reacts with oxygen gas in the air to form calcium oxide:

$$2Ca(s) + O_2(g) \rightarrow 2CaO(s)$$

   Suppose you have a "mystery mixture" of calcium and oxygen gas consisting of 12 moles of total reactants in a rigid, sealed container, but you do not know the relative amounts of each reactant. After the reaction between calcium and oxygen is complete, what is the **minimum possible** total number of moles (products and left-over reactants, if any) remaining in the product mixture?

   a) 1 mole b) 6 moles c) 8 moles d) 10 moles e) 12 moles

4. How many of the following statements are **always** true concerning a reaction represented by the following balanced chemical equation?

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

   I. If we have a greater number of moles of H_2 than O_2, then O_2 **must** be limiting.
   II. If we have an equal number of moles of H_2 and O_2 then H_2 **must** be limiting.
   III. If we have a greater number of moles of O_2 than H_2, then H_2 **must** be limiting.
   IV. If we have more mass of O_2 than H_2, then H_2 **must** be limiting.

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

5. Consider the reaction of nitrogen gas reacting with hydrogen gas to form ammonia:

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

   Suppose you react 28.02 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 nitrogen gas after the reaction is complete?

   a) 0.9098 g b) 1.361 g c) 1.998 g d) 2.729 g e) 6.048 g

6. How much water must be added to 250.0 mL of a 0.1000 *M* calcium chloride solution to make a solution that has a chloride ion concentration of 0.0800 *M*?

   a) 62.5 mL b) 250.0 mL c) 312.5 mL d) 375.0 mL e) 625.0 mL

7. A 100. g sample of potassium sulfate is dissolved in enough water to make 150.0 mL of solution. Determine the concentration of potassium sulfate in molarity.

a) 3.14 *M* b) 3.83 *M* c) 4.21 *M* d) 4.93 *M* e) 5.59 *M*

8. Consider aqueous solutions of sodium phosphate and calcium nitrate both with the same concentration (in molarity). You mix equal volumes of these solutions and allow the reaction to go to completion. How does the concentration of the sodium ion compare to the concentration of the phosphate ion after the reaction is complete?

a) The concentration of the sodium ion is three times greater than that of the phosphate ion.
b) The concentration of the sodium ion is six times greater than that of the phosphate ion.
c) The concentration of the sodium ion is nine times greater than that of the phosphate ion.
d) The concentrations of the sodium ion and the phosphate ion are equal.
e) Because the concentration of the phosphate ion is zero (it is limiting), the ratio of these concentrations is undefined.

9. Carbon reacts with oxygen gas to form both carbon monoxide and carbon dioxide. Suppose you react 10.0 moles of oxygen gas with an excess of carbon and you collect the products in a balloon at 25°C and 1.00 atm. You find the volume of the balloon to be 314.1 L. Which of the following is true about the product mixture?

a) The number of moles of CO_2 is greater than the number of moles of CO.
b) The number of moles of CO_2 is less than the number of moles of CO.
c) The number of moles of CO_2 is equal to the number of moles of CO.
d) We cannot determine the relative number of moles of products because with 10.0 moles of oxygen gas reacting, the final volume will always be 314.1 L.
e) We cannot determine the relative number of moles of products because we need to know the mass of carbon that reacted.

10. An equimolar (equal number of moles) mixture of hydrogen gas and oxygen gas is sparked to initiate the formation of water vapor. Assuming the reaction goes to completion, determine the ratio of **final pressure to initial pressure** of the gas mixtures if both samples are measured at the same volume and temperature.

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

11. Consider two samples of gas: hydrogen gas in a rigid, steel container, and helium gas in a container fitted with a massless, frictionless piston. Initially, both gases are at the same conditions of pressure, volume, and temperature. If you double the temperature (measured in Kelvin) of both samples, what is the ratio of the densities of **hydrogen gas to helium gas**?

a) 1:1 b) 2:1 c) 1:2 d) 1:4 e) 4:1

12, 13. Consider two 1.00 mole samples of gases (H_2 and O_2), both at the same volume and temperature.

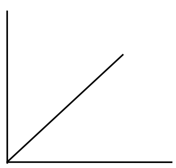
12. Determine the value of $\frac{collision\ frequency\ (Z_A)\ of\ H_2}{collision\ frequency\ (Z_A)\ of\ O_2}$ (for a given surface area, A)

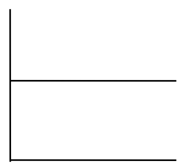
a) 0.25 b) 0.50 c) 1.0 d) 4.0 e) 16

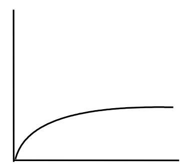
13. Determine the value of $\frac{change\ in\ momentum\ per\ collision\ with\ the\ walls\ for\ H_2}{change\ in\ momentum\ per\ collision\ with\ the\ walls\ for\ O_2}$

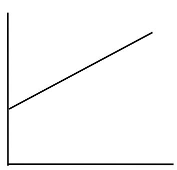
a) 0.25 b) 0.50 c) 1.0 d) 4.0 e) 16

14-16. Indicate which of the graphs below best represents each plot described in questions 14, 15, and 16. Note: the graphs may be used once, more than once, or not at all.

a)


b)


c)


d)


e)


14. Mean free path (λ) (y) vs. T (K) (x) for 1.00 mole of a non-ideal gas in a rigid sealed container.

15. Collision frequency (Z_A) (y) vs. T (K) (x) for 1.00 mole of an ideal gas in a container fitted with a massless, frictionless piston.

16. Volume (y) vs. molar mass (x) for 1.00 mole samples of a series of Noble gases behaving ideally in balloons at equal pressures and temperatures.

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17. For how many of the following reactions is the value of K_p **less than** the value of K at a temperature of 300K?

I. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$
II. $CO_2(g) + H_2(g) \rightleftharpoons CO(g) + H_2O(l)$
III. $3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$
IV. $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$
V. $CaCO_3(s) \rightleftharpoons CaO(s) + CO_2(g)$

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

18. Consider the system represented by $2H_2(g) + O_2(g) \rightleftharpoons 2H_2O(g)$ at equilibrium. How many of the following changes would shift the equilibrium position to the **left**?

I. Decreasing the temperature of the system at constant volume.
II. Addition of helium gas at constant pressure and temperature.
III. Addition of helium gas at constant volume and temperature.
IV. Decreasing the volume of the container at constant temperature.

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

19. Consider the decomposition of $C_5H_6O_3$ as follows:

$$C_5H_6O_3(g) \rightleftharpoons C_2H_6(g) + 3CO(g)$$

A sample of $C_5H_6O_3(g)$ is placed in a rigid, steel container. After the system comes to equilibrium, you note that the equilibrium pressure of $CO(g)$ is equal to the initial pressure of $C_5H_6O_3(g)$. Which of the following must be true concerning the **total pressure of the system at equilibrium**?

a) The total pressure at equilibrium is half the value of the initial pressure of $C_5H_6O_3(g)$.
b) The total pressure at equilibrium is equal to the initial pressure of $C_5H_6O_3(g)$.
c) The total pressure at equilibrium is twice as great as the initial pressure of $C_5H_6O_3(g)$.
d) The total pressure at equilibrium is three times as great as the initial pressure of $C_5H_6O_3(g)$.
e) The total pressure at equilibrium is four times as great as the initial pressure of $C_5H_6O_3(g)$.

20. The gases NH_3 (partial pressure = 5.0 atm) and O_2 (partial pressure = 5.0 atm) are placed in a steel rigid container. They react to equilibrium at constant temperature according to the following equation, for which $K_p = 1.0 \times 10^{-14}$:

$$4NH_3(g) + 5O_2(g) \rightleftharpoons 4NO(g) + 6H_2O(g)$$

Determine the equilibrium pressure of $NO(g)$.

a) 7.6×10^{-4} atm b) 0.0057 atm c) 0.033 atm d) 0.085 atm e) 0.13 atm