CHEMISTRY 202
Practice Hour Exam I
Fall 2023
Dr. D. DeCoste

Name __________**KEY**__________

Signature ______________________________

T.A. ______________________________

This exam contains 23 questions on 10 numbered pages. Check now to make sure you have a complete exam. You have two hours to complete the exam. Determine the **best** answer to the first 20 questions and enter these on the special answer sheet. Also, **circle your responses** in this exam booklet.

Show all of your work and provide complete answers to questions 21, 22 and 23.

1-20	(60 pts.)	______________
21	(20 pts.)	______________
22	(20 pts)	______________
23	(20 pts.)	______________
Total	(120 pts)	______________

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. Which of the following has the largest molar mass?

   a) sodium nitrate
   b) sodium hydroxide
   c) sodium carbonate
   d) sodium bicarbonate
   e) sodium chloride

2. A metallic oxide has a molar mass of 94.2 g/mol. What is the identity of the metal?

   a) Na b) K c) Mg d) Fe e) More information is needed.

3. The hydrocarbon propane (C_3H_8) combusts with oxygen gas to form carbon dioxide and water. Suppose you mix equal masses of propane and oxygen to completion and obtain 100.0 g of carbon dioxide. Determine the **initial total mass** of the reaction mixture.

   a) 66.79 g b) 154.6 g c) 204.1 g d) 242.4 g e) 320.0 g

4. A 4.00-g sample of a binary compound reacts with oxygen gas to form 1.80 g of water. Assuming that water is the only hydrogen containing product, which of the following could be part of the compound?

   a) B b) C c) N d) O e) F

5. Under the influence of heat, potassium chlorate ($KClO_3$) decomposes to form potassium chloride and oxygen gas. You have a 15.00 g mixture of potassium chlorate and potassium chloride. After heating this mixture to completion, you record the mass to be 12.54 g. Determine the percent by mass of potassium chlorate in the original mixture.

   a) 16.40% b) 41.87% c) 62.81% d) 83.60% e) 94.21%

6. What volume of a 0.05*M* NaCl 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) 166.7 mL b) 250.0 mL c) 500.0 mL d) 1.000 L e) 1.1000 L

7. Mixing aqueous solutions of lead(II) nitrate and potassium iodide results in the formation of a beautiful yellow solid. Consider mixing 150.0 mL of 0.1250*M* of lead(II) nitrate with 150.0 mL of 0.1250*M* potassium iodide. Determine the concentration of the lead(II) ion after the reaction is complete.

   a) 0 *M* b) 0.01563*M* c) 0.03125 *M* d) 0.06250*M* e) 0.1250*M*

8. Nitrogen gas reacts with hydrogen gas to produce ammonia gas (NH_3). Consider mixing equal masses of nitrogen and hydrogen gases in a container fitted with a massless and frictionless piston. Before any reaction, the volume of the container is 100. L. You allow the gases to react to completion at constant temperature. Determine the volume of the container once the reaction is complete.

a) 33.3 L
b) 50.0 L
c) 66.7 L
d) 86.6 L
e) More information is needed.

9. For which of the following constant volume cases is the number of collisions of gas particles with the walls of the container the **greatest**? Volume is the same in all cases.

a) 1.0 mol of helium gas at 125°C.
b) 1.0 mol of helium gas at 25°C.
c) 1.0 mol of oxygen gas at 25°C.
d) 2.0 mol of oxygen gas at 125°C.
e) 2.0 mol of oxygen gas at 150°C.

10. You mix equal masses of neon (Ne) gas and argon (Ar) gas in a 100.0-L vessel at 25ºC. The pressure of the gas mixture is 15.00 atm. Determine the total mass of the gas in the vessel.

a) 79.90 g b) 822.4 g c) 1236 g d) 1645 g e) 2451 g

11. Consider two samples of gases -- one of argon (Ar) gas and the other of helium (He) gas at 25ºC. The two gas samples have the same rate of effusion. Which of the following is closest to the temperature of the sample of the argon gas?

a) 3000ºC b) 2700ºC c) 100ºC d) 25ºC e) –240ºC

12. Consider two samples of helium in separate containers of equal volume and at equal pressure. Sample 1 has a Kelvin temperature that is 202 times that of Sample 2. Determine the ratio of:

[collision frequency (Z_A) in Sample 1] : [collision frequency (Z_A) in Sample 2]
(for a given area, A, of the walls of each container)

a) $\sqrt{\frac{1}{202}}$

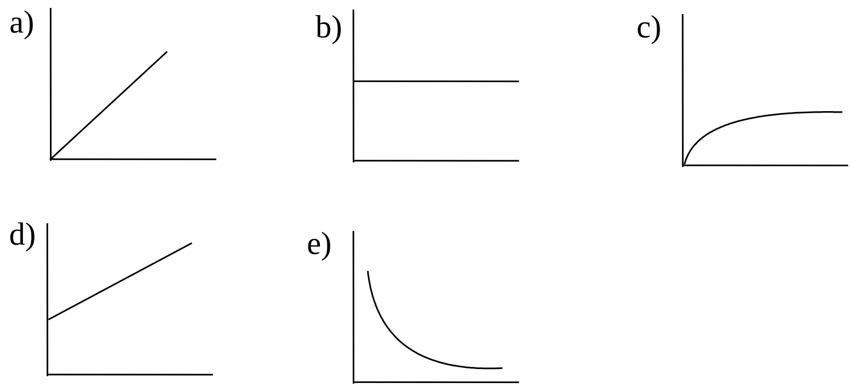
b) 202

c) $\frac{1}{202}$

d) $\sqrt{202}$

e) $202 \times \sqrt{202}$

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.



13. Mass of air in a hot air balloon (y) vs. T (K) (x) of the air in the hot air balloon. [e]

14. Pressure (y) vs. T (K) (x) for a sample of an ideal gas in a container fitted with a massless, frictionless piston. [b]

15. Mean free path (λ) (y) vs. P (x) for a 1.0 mole of an ideal gas at constant T. [e]

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16. Consider two systems at equilibrium. These are represented by:

I. $H_2(g) + F_2(g) \rightleftharpoons 2HF(g)$
II. $N_2(g) + 3H_2(g) \rightleftharpoons 2NH_3(g)$

In both systems the gaseous mixtures are in containers fitted with massless, frictionless pistons. Which of the following correctly describes the effect on equilibrium if helium gas is added to both systems?

a) Neither equilibrium will shift.
b) System I will not shift, but System II will shift to the right.
[c) System I will not shift, but System II will shift to the left.]
d) System I will shift to the left but System II will not shift.
e) System I will shift to the right but System II will not shift.

17. How many of the following statements concerning chemical equilibrium are **true**?

I. For a given reaction at a given temperature, there is one set of equilibrium conditions for the reactants and products.
II. The value of the equilibrium constant cannot change for a given equation under any conditions.
III. Adding an inert gas to a system at equilibrium cannot change the equilibrium position.
IV. Once a chemical system has reached equilibrium, no new product molecules are formed.

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

18. Consider an initial mixture of $SO_2(g)$ and $O_2(g)$ in which the partial pressure of $SO_2(g)$ is 6.28 atm and the partial pressure of $O_2(g)$ is 3.14 atm. The gases react as follows:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The value of the equilibrium constant, K_p, at this temperature is equal to 1.23×10^{-9}. Determine the partial pressure of $SO_3(g)$ at equilibrium. Assume constant volume and temperature.

a) 1.52×10^{-7} atm
b) 7.79×10^{-5} atm
c) 1.56×10^{-4} atm
d) 1.95×10^{-4} atm
e) 3.90×10^{-4} atm

19-20. Consider the reaction between nitrogen and oxygen gases to form nitrogen monoxide gas in a sealed, rigid container:

$$N_2(g) + O_2(g) \rightleftharpoons 2NO(g)$$

The container initially has an equimolar (same number of moles) mixture of nitrogen and oxygen gases at a certain temperature. The equilibrium constant (K) at this temperature for this reaction is equal to 36.0.

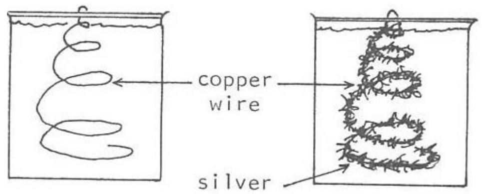
19. Determine the percent of the nitrogen gas that has reacted when equilibrium is reached.

a) 33.3% b) 42.9% c) 75.0% d) 85.7% e) 100.%

20. Given that all of the molecules are close to the same size and assuming the temperature is constant, which of the following is closest to the ratio of intermolecular collision frequencies in the original mixture (before any reaction has occurred) to that in the final mixture at equilibrium?

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

21. A classic chemistry demonstration is called "The Silver Tree" (we will see this in Chemistry 204 when we study redox reactions) in which copper metal reacts with silver nitrate and the products are silver metal and copper(II) nitrate. In this demonstration, a copper wire is coiled into a triangular tree shape and placed in an aqueous solution of silver nitrate. Over time, silver comes out of solution and is attached to the copper wire, so the "silver tree" is actually copper wire coated in silver metal:



You place a 10.00 g copper wire in 100.0 mL of a 1.000*M* $AgNO_3$ solution.

a. Assume you left this set-up overnight and the reaction went to completion. Determine the mass of the silver tree (assume all of the silver formed "sticks" to the tree). **Show and explain all work. [7 points].**

Mass of silver tree = 17.61 g

21. b. Suppose instead you let the reaction occur for several minutes and carefully remove the silver tree from the solution so that no silver metal falls off of the copper wire. Suppose as well that you are able to allow all of the solution to drip from the tree into the beaker (so that the final volume is still 100.0 mL) until the silver tree is dry. You carefully measure the mass of the silver tree and find that it is 12.216 g.

For this problem:

- **Determine the concentrations of Ag^+, Cu^{2+}, and NO_3^-** (in units of molarity) left in the beaker.
- **Determine the mass of the copper and the mass of silver on the tree**.
- **Show that mass is conserved** in the reaction.

Show and explain all work. [13 points]

Mass Cu: 9.075 g
Mass Ag: 3.141 g

[Ag^+] = 0.7089*M*
[Cu^{2+}] = 0.1456*M*
[NO_3^-] = 1.00*M*

Initial mass of Cu and Ag^+ = **20.79 g**

Final mass of "tree" and Ag^+ and Cu^{2+} = **20.79 g**

22. We discussed in lecture and in the videos that it is always helpful when considering gases to make note of four conditions: pressure, volume, temperature, and number of moles, and decide which factors are changing and which factors are constant. We also discussed three cases, and in your answers, you will want to consider the factors that are constant and that are changing:

Case I: The gas sample is in a sealed, rigid container.
Case II: The gas sample is in a container fitted with a massless frictionless piston
Case III: The gas sample is in an open, rigid container.

Use the ideas of the Kinetic Molecular Theory (KMT) and any relevant equations in your answers.

Suppose you have three gas samples, one for each of the cases described above. You wish to change the temperature of each gas sample such that the **number of collisions** of the gas particles with the walls of the container **increases by a factor of five**. Answer these two questions, treating the cases separately:

- Can a change in temperature in each case increase the number of collisions by a factor of five?
- If so, how do you change the temperature (by what factor) to do this for each case? If not, why not? Provide an **explanation using the KMT** along with **deriving a relationship** using relevant equations.

Show/explain all work. [20 points] Continue your answer on the next page, if needed.

Case I:

- If we wish to increase Z_A by a factor of 5, we need to **increase T (in terms of Kelvin) by a factor of 25.**

Case II:

- If we wish to increase Z_A by a factor of 5, we need to **decrease T (in terms of Kelvin) by a factor of 25.**

Case III:

- If we wish to increase Z_A by a factor of 5, we need to **decrease T (in terms of Kelvin) by a factor of 25.**

22. Continue your answer below, if needed.

23. In the following question you will be given two scenarios and the goal in both is to determine the initial pressure of the reactant gas. Please **show and explain** all work. Assume constant volume and temperature in both cases.

a. Consider the decomposition of dinitrogen tetroxide as follows: $N_2O_4(g) \rightleftharpoons 2NO_2(g)$. The value of the equilibrium constant, K_p, at a certain temperature is 0.500. The equilibrium mixture of $N_2O_4(g)$ and $NO_2(g)$ at this temperature has a total pressure of 6.00 atm. **Determine the initial pressure of dinitrogen tetroxide**. **Show/explain all work.** **[10 points]**

$P(N_2O_4)_0$ = 5.25 atm

23. b. Consider the decomposition of ammonia as follows: $2NH_3(g) \rightleftharpoons N_2(g) + 3H_2(g)$. The value of the equilibrium constant, K_p, at a certain temperature is 10.00. When pure ammonia is placed in an otherwise empty vessel at this temperature, equilibrium is reached when the partial pressure of ammonia is equal to the partial pressure of hydrogen gas. **Determine the initial pressure of ammonia. Show/explain all work. [10 points]**

$P(NH_3)_0$ = 9.129 atm