CHEMISTRY 202
Hour Exam I
September 21, 2023
Dr. D. DeCoste

Name _____**KEY**_____

Signature _____

T.A. _____

This exam contains 23 questions on 9 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 contains the **greatest** percent by mass oxygen?

   a) Sodium bicarbonate
   b) Potassium phosphate
   c) Barium hydroxide
   d) Potassium nitrate
   e) Sodium sulfate

2. Which of the following is the closest estimation of the number of atoms that make up an adult human? 1 kg is about 2.2 lbs. on Earth.

   a) 10^{18} b) 10^{23} c) 10^{27} d) 10^{32} e) 10^{37}

3. Iron (Fe) reacts with oxygen gas to form iron(II) oxide and iron(III) oxide. You react 1.00 mole of iron with 20.0 g of oxygen gas to form a mixture of the oxides, with no leftover reactants. Determine the mass of iron(III) oxide produced.

   a) 35.9 g b) 39.9 g c) 71.9 g d) 75.9 g e) 79.9 g

4. You react **equal masses** of reactants together. For which of the following cases is oxygen gas **not** the limiting reactant?

   a) Reacting calcium metal with oxygen gas to produce calcium oxide.
   b) Reacting methane (CH_4) with oxygen gas to produce carbon dioxide and water.
   c) Reacting hydrogen and oxygen gases to produce water.
   d) Oxygen gas limits all of the reactions described above (a-c).
   e) Oxygen gas does not limit any of the three reactions described above (a-c).

5. You have a 100.0 g mixture of methane (CH_4) and oxygen gas, which react to produce carbon dioxide and water. What is the **maximum mass** of carbon dioxide that can be produced?

   a) 46.21 g b) 54.98 g c) 68.75 g d) 100.0 g e) More data required.

6. Consider aqueous solutions of barium nitrate and potassium hydroxide, each with the **same concentration** as measured in units of molarity. You mix 100.0 mL of the barium nitrate solution with the potassium hydroxide solution such that the concentration of the nitrate ions is **four times** that of the concentration of the barium ions in solution **after the reaction** is complete. What volume of potassium hydroxide solution was added?

   a) 16.7 mL b) 33.3 mL c) 50.0 mL d) 66.7 mL e) 100.0 mL

7. Consider 0.100*M* aqueous solutions of sodium chloride and silver nitrate. What volume of the 0.100*M* sodium chloride solution must be added to 100.0 mL of the 0.100*M* silver nitrate solution such that the concentration of the silver ions in the final solution is 0.0200*M*?

   a) 16.7 mL b) 33.3 mL c) 50.0 mL d) 66.7 mL e) 100.0 mL

8. When 100.0 mL of a 0.100*M* solution of magnesium nitrate is mixed with 100.0 mL of a 0.100*M* solution of sodium nitrate, what is the concentration of the nitrate ions?

a) 0.0500*M* b) 0.100*M* c) 0.150*M* d) 0.200*M* e) 0.300*M*

9. When solid potassium chlorate ($KClO_3$) is heated, the products are potassium chloride and oxygen gas. A 15.0 g sample of potassium chlorate is heated for a bit of time and the oxygen gas is collected in a balloon. The volume of the balloon is measured to be 3.14 L at 1.00 atm and 25ºC. Which of the following best describes the situation?

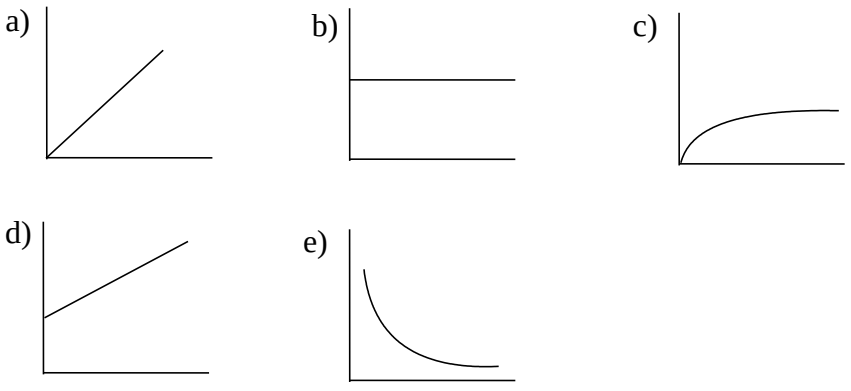
a) There is $KClO_3$ remaining after heating and 9.57 g of potassium chloride is produced.
b) There is $KClO_3$ remaining after heating and 9.12 g of potassium chloride is produced.
c) There is $KClO_3$ remaining after heating and 6.38 g of potassium chloride is produced.
d) All of the potassium chlorate was converted to potassium chloride and oxygen.
e) The data are incorrect. There was not enough oxygen produced to make a balloon that size at those conditions.

10. Consider a mixture of **equal masses** of helium (He) gas and neon (Ne) gas in a rigid vessel. 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) 5.042 e) 11.32

11-13. Indicate which of the graphs below best represents each plot described in questions 11, 12, and 13. Note: the graphs may be used once, more than once, or not at all.



11. Change in momentum per impact (y) vs. T (x) for an ideal gas at constant V. c

12. Collision frequency (Z_A) (y) vs. P (x) for an ideal gas at constant V and T. a

13. Volume (y) vs. T (ºC) (x) for a sample of an ideal gas in a container fitted with a massless, frictionless piston. d

14. Consider a sample of neon gas (Ne) in a rigid container at 3.14 atm. You add krypton gas (Kr) to the container at constant temperature until the density of the mixture is the same as the density of nitrogen gas. The conditions of pressure and temperature of the nitrogen gas are the same as the final mixture of neon and krypton. What is the **total pressure** in the container of neon and krypton?

a) 3.58 atm b) 4.76 atm c) 5.83 atm d) 6.28 atm e) 25.5 atm

15. You add equal masses of dry ice (solid carbon dioxide) and liquid nitrogen to a balloon and seal it. This system achieves room conditions (1.00 atm and 25ºC) after all of the dry ice sublimates and the liquid nitrogen boils. The final volume of the balloon is found to be 97.8 L. Determine the **mass of the dry ice** that was added to the balloon.

a) 43.6 g b) 68.5 g c) 108 g d) 137 g e) 144 g

16. Recall the lecture demonstration in which we reacted aqueous hexaaquacobalt(II) ions with concentrated hydrochloric acid, as represented by the following equation:

$$\underset{\text{(red)}}{Co(H_2O)_6^{2+}(aq)} + 4Cl^-(aq) \rightleftharpoons \underset{\text{(blue)}}{CoCl_4^-(aq)} + 6H_2O(l)$$

Which of the following best describe(s) and explain(s) the color of the system after adding water?

I. The solution turned red because water is part of a reactant ion.
II. The solution turned blue because water is part of a reactant ion.
III. The solution turned red because we added more product and so equilibrium shifted to the reactant side.
IV. The solution turned blue because we added more product and so equilibrium shifted to the product side.

a) I, III b) II, IV c) II d) III e) None of these.

17. The gas SO_3 decomposes to form $SO_2(g)$ and $O_2(g)$. You place a sample of pure SO_3 gas in an evacuated rigid steel container and record the pressure. You note that when the system reaches equilibrium at constant temperature, the pressure has increased by 40.0%. What percent of the SO_3 has decomposed at equilibrium?

a) 10.0% b) 20.0% c) 40.0% d) 60.0% e) 80.0%

18. A 100.1 g sample of solid calcium carbonate is placed in a 15.0-L evacuated rigid steel container. Calcium carbonate decomposes to produce solid calcium oxide and carbon dioxide gas. The reaction achieves equilibrium at 25ºC and the mass of solid remaining in the container is measured to be 60.48 g. Determine the value of the equilibrium constant, K_p, for the reaction written in standard form.

a) 0.645 b) 1.47 c) 8.10 d) 13.2 e) 22.0

19. In an evacuated, rigid steel container at constant temperature you react an equal number of moles of $PCl_3(g)$ and $Cl_2(g)$ so that the total pressure is 16.0 atm. The system reaches equilibrium according to the following chemical equation:

$$PCl_3(g) + Cl_2(g) \rightleftharpoons PCl_5(g)$$

After equilibrium is reached, you note that the partial pressures of all three gases are equal. Determine the value of the equilibrium constant, K_p, for the reaction as written above.

a) 0.0313 b) 0.0625 c) 0.125 **d) 0.250** e) 1.00

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 $K_p = 1.0 \times 10^{18}$.

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

Determine the equilibrium pressure of $O_2(g)$.

a) 2.4×10^{-17} atm b) 1.2×10^{-11} atm c) 1.3×10^{-3} atm **d) 6.5×10^{-3} atm** e) 3.3×10^{-2} atm