

GASES AND THEIR BEHAVIOR

1. (3 points) In order to use the ideal gas law, we must express the pressure in units of atmospheres. Express 816 mm Hg in atmospheres.

816 mm Hg = _____ atmospheres

2. (3 points) Air contains 22% O₂ (on a mole basis). If the pressure of air in this room is 745 mm Hg, what is the partial pressure of O₂?
- (a) 220 mm Hg
(b) 164 mm Hg
(c) 581 mm Hg
(d) 745 mm Hg
(e) None of the above

3. (9 points) You have a mixture of four gases: CO, CO₂, O₂, and NH₃.

- (a) Rank the four gases in order of their relative velocities at 25 °C.

slowest gas

_____ —increasing speed→ _____

fastest gas

- (b) If you have a 300. L tank of the four gases above, and the CO partial pressure is 41.8 mm Hg at 25°C, how many moles of CO are in the tank?

(a) 8.04 mol CO

(b) 5.13 mol CO

(c) 0.674 mol CO

(d) none of the above

- (c) The CO pressure in the 300. L tank is 41.8 mm Hg at 25 °C. If the gas is released into a room with a volume of 2.0 x 10⁴ L, what is the partial pressure of the CO?

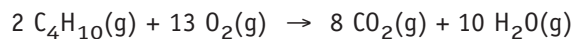
(a) 1.25 x 10⁴ mm Hg

(b) 20.6 mm Hg

(c) 0.63 mm Hg

(d) 8.4 x 10⁻⁵ mm Hg

4. (6 points) Butane reacts with O_2 according to the equation



Suppose you mix C_4H_{10} with O_2 in the correct stoichiometric ratio in a 1.00 L flask. If the pressure of O_2 is 100 mm Hg, the partial pressure of the C_4H_{10} must be _____ mm Hg. After C_4H_{10} and O_2 have been consumed, the pressure of CO_2 in the 1.00 flask is _____ mm Hg, and the total pressure of the products (CO_2 and H_2O in the 1.00 L flask) must be _____ mm Hg.

5. (3 points) Chloroform is a common solvent, and it vaporizes readily. If the pressure of 1.563 g of chloroform in a 1.25 L flask is 195 mm Hg at $25.0^\circ C$, what is the formula of chloroform?

- (a) CH_3Cl
- (b) CH_2Cl_2
- (c) $CHCl_3$
- (d) CCl_4
- (e) none of the above

6. (8 points) You have two flasks, each with a volume of 2.00 L:

A: H_2 at $0^\circ C$ and 1 atm pressure

B: CO_2 at $0^\circ C$ and 2 atm pressure

- (a) Which flask contains the greater number of molecules?
 - (i) flask A
 - (ii) flask B
 - (iii) the flasks each have the same number of molecules
- (b) In which flask is the average kinetic energy of the molecules greater?
 - (i) flask A
 - (ii) flask B
 - (iii) the average kinetic energies are the same
- (c) In which flask is the average molecular velocity greater?
 - (i) flask A
 - (ii) flask B
 - (iii) the average velocities of the molecules are the same
- (d) If the H_2 in flask A is moved to flask B (at $0^\circ C$), the partial pressure of the H_2 gas in flask B is _____ atm

7. (9 points) Chlorine dioxide, ClO_2 , the gas used to kill anthrax spores, can be made by the reaction of chlorine with sodium chlorite.

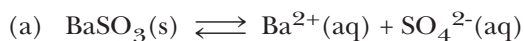


Suppose you react excess NaClO_2 with Cl_2 gas. The Cl_2 gas has a pressure of 1050 mm Hg in a 1.45-L flask at 25 °C. What mass of ClO_2 can be prepared? (Molar mass of $\text{ClO}_2 = 67.5 \text{ g/mol}$).

Please show your work carefully and completely.

CHEMICAL EQUILIBRIA

1. (4 points) Write the equilibrium constant expression for each of the following reactions:

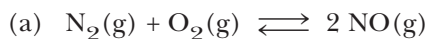


$K_c =$

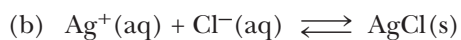


$K_c =$

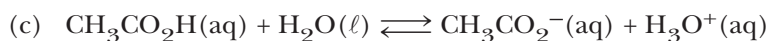
2. (6 points) Based on the value of K , describe each of the following reactions as product-favored or reactant-favored.



$K = 1.7 \times 10^{-3}$ _____

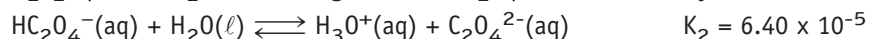
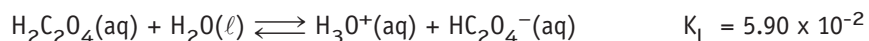


$K = 5.56 \times 10^9$ _____

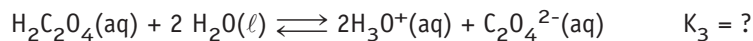


$K = 1.8 \times 10^{-5}$ _____

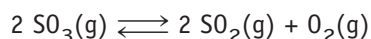
3. (3 points) OWL question: Equilibrium constants for the first two ionization steps of oxalic acid are known at 25 °C.



What is the ionization constant for the overall reaction?

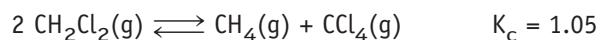


- (a) $K_3 = 1.08 \times 10^{-3}$
- (b) $K_3 = 6.40 \times 10^{-5}$
- (c) $K_3 = 3.78 \times 10^{-6}$
- (d) $K_3 = 9.22 \times 10^2$
- (e) none of the above.
4. (3 points) OWL question: Consider the following reaction:



What is the value of K_c if the concentrations at equilibrium are 0.378 M for $\text{SO}_3(\text{g})$, 0.0507 M for $\text{SO}_2(\text{g})$, and 0.0559 M for $\text{O}_2(\text{g})$ at 1360 K?

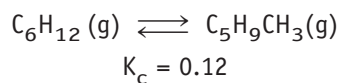
- (a) $K_c = 3.8 \times 10^{-4}$
- (b) $K_c = 0.0010$
- (c) $K_c = 0.0198$
- (d) $K_c = 1000$
- (e) none of the above
5. (3 points) OWL question: The equilibrium constant for the following reaction is 1.05 at 350K.



If an equilibrium mixture of the three gases at 350K contains 0.0206 M $\text{CH}_2\text{Cl}_2(\text{g})$ and 0.0163 M CH_4 , what is the the equilibrium concentration of CCl_4 ?

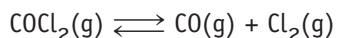
- (a) $[\text{CCl}_4] = 1.33 \text{ M}$
- (b) $[\text{CCl}_4] = 0.754 \text{ M}$
- (c) $[\text{CCl}_4] = 0.0272 \text{ M}$
- (d) $[\text{CCl}_4] = 0.000726 \text{ M}$
- (e) none of the above

6. (3 points) Cyclohexane, C_6H_{12} , can isomerize to methylcyclopentane on heating.



If a mixture consists of 0.023 mol of C_6H_{12} and 0.0037 mol of $C_5H_9CH_3$, what answer describes the system?

- (a) The system is at equilibrium.
- (b) The system is not at equilibrium. It proceeds to the *right* to reach equilibrium.
- (c) The system is not at equilibrium. It proceeds to the *left* to reach equilibrium.
7. (6 points) Carbonyl chloride, $COCl_2$, decomposes on heating to CO and Cl_2 .



Suppose that 0.224 mol of $COCl_2$ was placed in a 1.00 L flask and heated. When equilibrium is achieved, $[CO] = 0.0477$ M.

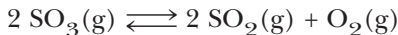
Part 1: What is the concentration of $COCl_2$ at equilibrium?

- (a) $[COCl_2] = 0.0477$ M
- (b) $[COCl_2] = 0.176$ M
- (c) $[COCl_2] = 0.224$ M
- (d) $[COCl_2] = 0.272$ M

Part 2: What is the value of K_c for the decomposition of $COCl_2$?

- (a) $K_c = 0.0102$
- (b) $K_c = 0.0129$
- (c) $K_c = 0.271$
- (d) $K_c = 77.5$

8. (8 points) OWL question: Consider the following system at equilibrium where $\Delta H^\circ = -198 \text{ kJ}$, and $K_c = 2.90 \times 10^{-2}$ at 1150 K:



Part 1: If the *temperature* of the equilibrium system is suddenly increased, the value of K_c

- (a) increases
- (b) decreases
- (c) remains the same

If the temperature is suddenly increased, the concentration of O_2 will (increase) (decrease) (stay the same) _____

Part 2: If SO_3 is added to a system at equilibrium, the reaction must

- (a) Run in the forward direction to re-establish equilibrium.
- (b) Run in the reverse direction to re-establish equilibrium.
- (c) Remain the same. It is still at equilibrium.

Part 3: If the *volume of the flask* is suddenly reduced, the reaction must

- (a) Run in the forward direction to re-establish equilibrium.
- (b) Run in the reverse direction to re-establish equilibrium.
- (c) Remain the same. It is still at equilibrium

SOLUBILITY (K_{sp} values are in Appendix J, page A-28)

1. (2 points) Name or give the formula for two *insoluble salts based on the carbonate ion*.

(a) _____

(b) _____

2. (6 points) In each case below, decide if a precipitate will form when the indicated reagents are mixed (*answer yes or no*)

_____ $\text{Pb}(\text{NO}_3)_2 + \text{HF}$

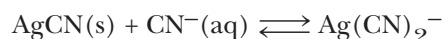
_____ $\text{BaCl}_2 + \text{Na}_2\text{SO}_4$

_____ $\text{Ba}_3(\text{PO}_4)_2 + \text{HCl}$

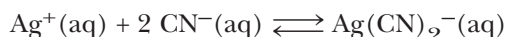
3. (3 points) What will happen when silver ions are added to a solution containing 0.10 M Br^- ions and 0.10 M PO_4^{3-} ions?

- (a) AgBr will precipitate first followed by a precipitate of Ag_3PO_4
- (b) Ag_3PO_4 will precipitate first followed by a precipitate of AgBr
- (c) Ag_3PO_4 and AgBr will precipitate at the same time
- (d) Neither Ag_3PO_4 nor AgBr will precipitate.

4. (3 points) What is the molar solubility of $\text{Fe}(\text{OH})_2$, iron(II) hydroxide?
- (a) Solubility = 7.9×10^{-15} mol/L
- (b) Solubility = 8.9×10^{-8} mol/L
- (c) Solubility = 2.0×10^{-5} mol/L
- (d) Solubility = 1.3×10^{-5} mol/L
5. (3 points) (SQ 19-53) What is the solubility of BaF_2 in water that contains 0.086 M KF?
- (a) 0.086 mol BaF_2 /L
- (b) 7.4×10^{-3} mol BaF_2 /L
- (c) 2.3×10^{-4} mol BaF_2 /L
- (d) 2.0×10^{-5} mol BaF_2 /L
6. (3 points) An important part of doing qualitative analysis is being able to dissolve precipitates. Silver(I) ion forms insoluble AgCN on adding CN^- . But what happens if you add too much CN^- . Will the AgCN remain a precipitate or will it dissolve in the presence of excess CN^- ion? Prove your answer by finding an equilibrium constant for the reaction



You know that K_{sp} for $\text{AgCN} = 1.2 \times 10^{-16}$ (Appendix J) and that the equilibrium constant for the following reaction is 5.6×10^{18} (Appendix K).



LABORATORY (3 points)

It is a bright, sunny day, but you would really rather not be in the lab doing the analysis of the silver group cations (Ag^+ , Pb^{2+} , and Hg_2^{2+}). So, you try to get through it as quickly as possible. Your instructor gives you your unknown, but in your haste you spill all but 10 drops of it. Oh, well. You add two drops of 6 M HCl, and see a white precipitate. On your way to the front of the lab, you grab a bottle of 6 M NH_3 and add 10 drops. The whole precipitate dissolves! You know exactly what is in there, and triumphantly tell your wonderful lab instructor

I definitely have _____

I definitely do not have _____

I am clueless about _____