

# Monopoly Problems

Andrew Ye and Diva Shah

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## Contents

1	Unit 1: Atomic Structure and Properties	3
2	Unit 2: Molecular and Ionic Compound Structure and Properties	4
3	Unit 3: Intermolecular Forces and Properties	6
4	Unit 4: Chemical Reactions	7
5	Unit 5: Kinetics	7
6	Unit 6: Thermodynamics	9
7	Unit 7: Equilibrium	10
8	Unit 7: Acids and Bases	11

## 1 Unit 1: Atomic Structure and Properties

### Problem 1

Calculate the number of moles in a  $7.89\text{kg}$  sample of  $\text{C}_9\text{H}_8\text{O}_4$

### Problem 2

Given this graph, what is true about the element depicted



- (a) In an average sample of the element, less than 20% of the atoms have an atomic mass of  $66u$ .
- (b) The most abundant isotope of the element has an atomic mass of  $64u$ .
- (c) The element has an average atomic mass of  $64u$ .
- (d) The element has an average atomic mass between 66 and  $68u$ .

### Problem 3

What is the percent composition of Carbon in  $\text{C}_{13}\text{H}_{18}\text{O}_2$ ?

### Problem 4

A compound contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen. What is the empirical formula.

### Problem 5

What is the full electron configuration of mercury?

### Problem 6

Below, the photoelectron spectra of the 2s electrons of Be and Mg are shown.



Is peak *X* the peak associated with Be or Mg?

### Problem 7

What are the periodic trends of ionization energy, atomic radius, and electronegativity? Why?

## 2 Unit 2: Molecular and Ionic Compound Structure and Properties

### Problem 8

Which of the following bonds is likely to have the most ionic character?

- (a) H — F
- (b) C — O
- (c) Na — F
- (d) Mg — O

### Problem 9

Based on the information in the table, which of the following arranges the bonds in order of decreasing polarity?

Element	Electronegativity
H	2.2
N	3.0
F	4.0
Cl	3.2
Se	2.6
I	2.7

- (a)  $\text{Se} - \text{N} > \text{H} - \text{I} > \text{Cl} - \text{F}$   
 (b)  $\text{H} - \text{I} > \text{Se} - \text{N} > \text{Cl} - \text{F}$   
 (c)  $\text{Cl} - \text{F} > \text{H} - \text{I} > \text{Se} - \text{N}$   
 (d)  $\text{Cl} - \text{F} > \text{Se} - \text{N} > \text{H} - \text{I}$

### Problem 10

Why is the lattice energy of CsF smaller than the lattice energy of KF?

### Problem 11

What type of structure do metallic elements form and through what bonds?

### Problem 12

What are the two types of metallic alloys and what are their differences?

### Problem 13

Draw a Lewis Diagram for Acetic Acid  $\text{CH}_3\text{COOH}$ .

### Problem 14

Draw the Lewis Diagram for  $\text{CO}_2$

### Problem 15

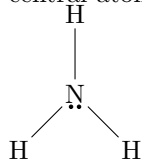
Draw the Lewis Diagram(s) for ozone,  $\text{O}_3$

### Problem 16

Write the formal charges for all three molecules above.

### Problem 17

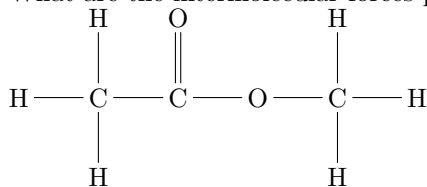
What is the electron geometry, molecular geometry, and hybridization of the central atom in this molecule.



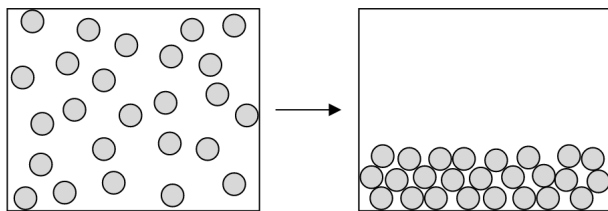
## 3 Unit 3: Intermolecular Forces and Properties

### Problem 18

What are the intermolecular forces present among these molecules.



### Problem 19



What phase transition is this?

### Problem 20

Originally, a sample of gas is in a rigid container at  $299K$  and  $0.70atm$ . The student increases the temperature of the  $CO_2(g)$  in the container to  $425K$ .

- What does raising the temperature do to the motion of the molecules?
- What is the pressure at  $425K$ ?
- In terms of Kinetic Molecular Theory, why does the pressure of gas change as it is heated?

### Problem 21

A  $60.3g$  of  $Be(OH)_2$  is dissolved in enough water to produce  $1.75L$  of solution. Calculate the concentration of  $OH^-$  ions.

### Problem 22

Describe the photoelectric effect.

## 4 Unit 4: Chemical Reactions

### Problem 23

Balance this reaction:  $\text{C}_5\text{H}_{10} + \text{O}_2 \longrightarrow \text{CO}_2 + \text{H}_2\text{O}$

### Problem 24

Balance this redox reaction:  $\text{MnO}_4^- + \text{I}^- \longrightarrow \text{I}_2 + \text{Mn}^{2+}$

### Problem 25

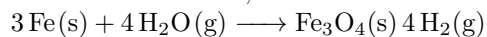
Aqueous  $\text{FeCl}_3$  reacts with  $\text{KOH}$  to produce a solid precipitate of  $\text{Fe}(\text{OH})_3$  and aqueous  $\text{KCl}$ . What is the balanced net ionic equation?

### Problem 26

What is the difference between physical changes and chemical changes?

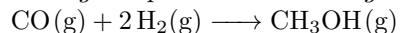
### Problem 27

$\text{H}_2\text{O}$  and  $\text{Fe}$  are reacted according to the reaction below. There was initially  $36.0\text{g}$   $\text{H}_2\text{O}$  and  $67.0\text{g}$   $\text{Fe}$ . What is the limiting reactant, how much of the excess reactant will remain, and how much iron oxide is produced?



### Problem 28

A  $56\text{kg}$  sample of  $\text{CO}$  and  $6.0\text{kg}$  sample of  $\text{H}_2$  are combined into a closed vessel.

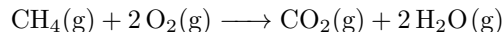


How many moles of  $\text{CH}_3\text{OH}(\text{g})$  have been produced?

## 5 Unit 5: Kinetics

### Problem 29

For this reaction:



What would be rate be in terms of each reactant and product.

$\text{CH}_4$  rate =

$\text{O}_2$  rate =

$\text{CO}_2$  rate =

$\text{H}_2\text{O}$  rate =

### Problem 30

If the rate of disappearance of  $\text{CH}_4$  equals  $5.0 \frac{M}{s}$  for the above reaction, what is the rate of appearance of  $\text{H}_2\text{O}$ ?

### Problem 31

For the above reaction, what is the reaction rate if  $\text{O}_2$  decreases from  $0.1M$  to  $0.04M$  in  $125ms$ ?

### Problem 32

$\text{A(aq)} + 2\text{B(aq)} \longrightarrow \text{Products}$

Experiment	$[\text{A}]_0$	$[\text{B}]_0$	Initial Rate
1	$0.10M$	$0.10M$	$1.0 \times 10^{-2} \frac{M}{s}$
2	$0.3M$	$0.10M$	$9.0 \times 10^{-2} \frac{M}{s}$
3	$0.3M$	$0.15M$	$9.0 \times 10^{-2} \frac{M}{s}$

What is the rate law?

### Problem 33

$\text{N}_2\text{O}_5$  decomposes by a 1st order reaction with  $k = 4.80 \times 10^{-4} \frac{1}{s}$ . What is the concentration of  $\text{N}_2\text{O}_5$  after 825 seconds if the initial concentration is  $0.0165M$ ? What is the half-life for this reaction?

### Problem 34

**This problem relates to problem 35 as well**

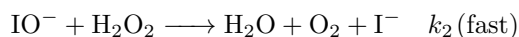
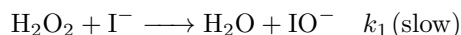
The reaction  $2\text{C}_4\text{H}_6(\text{g}) \longrightarrow \text{C}_8\text{H}_{12}(\text{g})$  is a 2nd order reaction with  $k = 4.0 \times 10^{-4} \frac{1}{Ms}$ . If the initial concentration of  $\text{C}_4\text{H}_6$  is  $0.100M$  what is the concentration after 6 days?

### Problem 35

How long does it take for the concentration to drop to  $0.085M$ ?

### Problem 36

What is the net chemical reaction and predict the experimental rate law for a chemical reaction with this chemical mechanism.

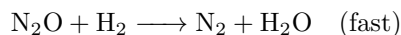
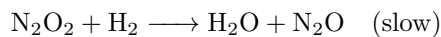
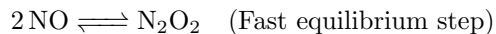


Also identify catalysts and intermediates.



### Problem 37

Predict the experimental rate law for a chemical reaction that proceeds by the following mechanism:



## 6 Unit 6: Thermodynamics

### Problem 38

It takes  $1.8 \times 10^{-19}$  calories of energy to break an O — H bond in water. How much energy does it take to break all of the O — H bonds in 50.0 grams of water?

### Problem 39

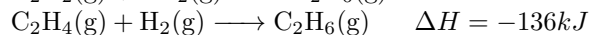
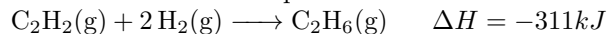
120. grams of an unknown metal at  $100.^\circ\text{C}$  is dropped in a styrofoam cup that contains 100.0mL of water that is at  $20.0^\circ\text{C}$ . After some times, the final temperature of the equilibrated system is measured to be  $27.3^\circ\text{C}$ . What is the specific heat capacity of the metal?

### Problem 40

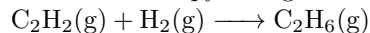
How much heat energy is required to vaporize 5.0 liters of  $\text{H}_2\text{O}(\text{l})$  where the heat of vaporization of water is  $40.72 \frac{\text{kJ}}{\text{mol}}$ .

### Problem 41

Given these chemical equations



Find the enthalpy change for



### Problem 42

For  $\text{C}_2\text{H}_5\text{OH}(\text{l}) + 2\text{O}_2(\text{g}) \longrightarrow 2\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l}) \quad \Delta H = -1371\text{kJ}$ . If 1.5mol of oxygen is used, how much energy is released?

### Problem 43

When temperature increases, does entropy increase or decrease?

### Problem 44

If the standard entropies for  $\text{H}_2\text{O}(\text{g})$ ,  $\text{H}_2(\text{g})$ , and  $\text{O}_2$  are 188.83, 130.58, and 205.0 respectively, what is the entropy change for  $2\text{H}_2\text{O}(\text{g}) \longrightarrow 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$ ?

### Problem 45

What is  $\Delta S_{\text{universe}}$  for the equation  $\text{CH}_4(\text{g}) + 2\text{O}_2(\text{g}) \rightleftharpoons \text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{g})$  where  $\Delta H = -802.2 \frac{\text{kJ}}{\text{mol}}$ . Use the standard entropy values above and note that  $S^\circ = 213.7$  and  $186.1$  for  $\text{CO}_2(\text{g})$  and  $\text{CH}_4(\text{g})$  respectively.

### Problem 46

For  $\text{N}_2(\text{g}) + 2\text{H}_2(\text{g}) \rightleftharpoons 2\text{NH}_3(\text{g})$  where  $\Delta H = -91.8 \text{ kJ}$  and  $\Delta S^\circ = -197.3 \frac{\text{J}}{\text{K}}$ . Calculate  $\Delta G^\circ$  at  $1000\text{K}$

### Problem 47

For  $2\text{H}_2\text{O}(\text{g}) \rightleftharpoons 2\text{H}_2(\text{g}) + \text{O}_2(\text{g})$   $\Delta H^\circ = 483.6 \text{ kJ}$ . Will the reaction form more or less product when temperature is increased.

## 7 Unit 7: Equilibrium

### Problem 48

What is the concentration equilibrium constant for the reaction  $\text{CO}(\text{g}) + 3\text{H}_2(\text{g}) \rightleftharpoons \text{CH}_4(\text{g}) + \text{H}_2\text{O}(\text{g})$

### Problem 49

If  $K_c = 3.91$  at  $1200\text{K}$ , Will the reactants shift towards products, reactants, or stay the same if the reaction mixture contains  $[\text{CO}] = 0.0200\text{M}$ ,  $[\text{H}_2] = 0.0200\text{M}$ ,  $[\text{CH}_4] = 0.00100\text{M}$ , and  $[\text{H}_2\text{O}] = 0.00100\text{M}$ ?

### Problem 50

For this chemical reaction  $2\text{CH}_4(\text{g}) \rightleftharpoons \text{C}_2\text{H}_2(\text{g}) + 3\text{H}_2(\text{g})$ ,  $K_p = 2.0 \times 10^{-6}$ .  $14\text{atm}$  of methane gas is put into the reaction vessel. What is the expected partial pressure of  $\text{C}_2\text{H}_2(\text{g})$  at equilibrium.

### Problem 51

For this reaction  $\text{NH}_4\text{HS}(\text{s}) \rightleftharpoons \text{NH}_3(\text{g}) + \text{H}_2\text{S}(\text{g})$ ,  $K_c = 0.16$ . What is the molar concentration of each product if  $250\text{g}$  of ammonium hydrogen sulfide is introduced into a  $2.0\text{L}$  flask and allowed to reach equilibrium.

**Problem 52**

What is the molar solubility of AgCl in water at  $24^{\circ}\text{C}$  where  $K_{sp} = 1.8 \times 10^{-10}$  for AgCl at this temperature.

**Problem 53**

What is the solubility of  $\text{Ca}_3(\text{PO}_4)_2$  in water at  $25^{\circ}\text{C}$  in where  $K_{sp} = 1.2 \times 10^{-29}$ .

**Problem 54**

15mg of  $\text{CaF}_2$  dissolves in 1.00L of water at  $25^{\circ}\text{C}$ . What is  $K_{sp}$  for  $\text{CaF}_2$  at this temperature?

**Problem 55**

What is the molar concentration of  $\text{OH}^-$  in an aqueous 1.3M HCl solution at  $24^{\circ}\text{C}$ ?

**Problem 56**

What is the pH of an aqueous solution of 0.050M  $\text{HNO}_3$  solution at  $25^{\circ}\text{C}$ ?

**Problem 57**

What is the pH of a weak acid with a  $K_a = 2.6 \times 10^{-5}$ ?

**8 Unit 8: Acids and Bases****Problem 58**

Calculate the pH of a solution that is 0.5M  $\text{CH}_3\text{COOH}$  and 0.10M  $\text{KCH}_3\text{COO}$ .

**Problem 59**

Calculate the pH of a solution that is 0.10M  $\text{CH}_3\text{COOH}$  and 0.50M  $\text{KCH}_3\text{COO}$ .