Monopoly Problems

Andrew Ye and Diva Shah

May 2024

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 **8**

6 Unit 6: Thermodynamics **10**

7 Unit 7: Equilibrium **11**

8 Unit 8: Acids and Bases **12**

9 Unit 9: Applications of Thermodynamics **13**

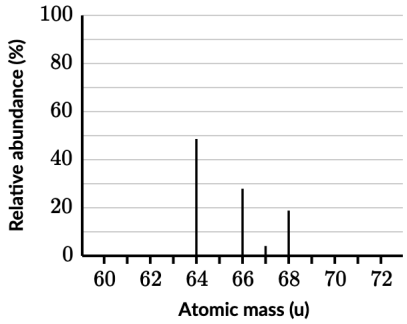
1 Unit 1: Atomic Structure and Properties

Problem 1

Calculate the number of moles in a $7.89kg$ sample of $C_9H_8O_4$

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 $C_{13}H_{18}O_2$?

Problem 4

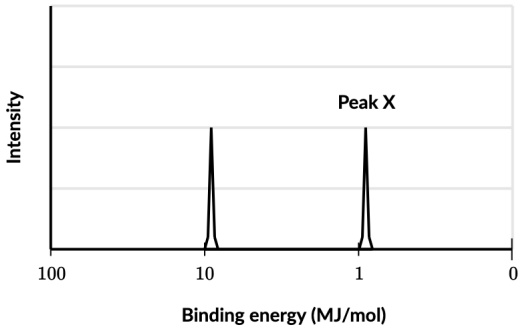
A compound contains 32.38% sodium, 22.65% sulfur, and 44.99% oxygen. What is the emperical forumula.

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) Se —— N > H —— I > Cl —— F
(b) H —— I > Se —— N > Cl —— F
(c) Cl —— F > H —— I > Se —— N
(d) Cl —— F > Se —— N > H —— 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 there differences?

Problem 13

Draw a Lewis Diagram for Acetic Acid CH_3COOH.

Problem 14

Draw the Lewis Diagram for CO_2

Problem 15

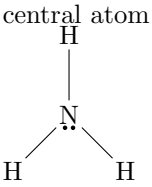
Draw the Lewis Diagram(s) for ozone, O_3

Problem 16

Write the formal charges for all three molecules above.

Problem 17

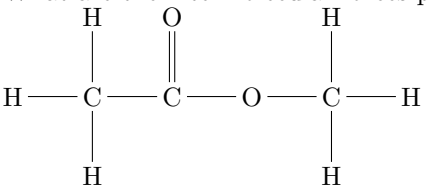
What is the electron geometry, molecular geometry, and hybridization of the central atom in this molecule.



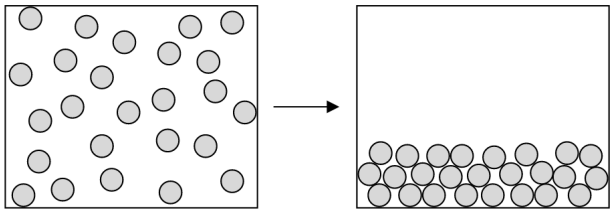
3 Unit 3: Intermolecular Forces and Properties

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 $425K$.
(a) What does raising the temperature do to the mostion of the molecules?
(b) What is the pressure at $425K$?
(c) 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

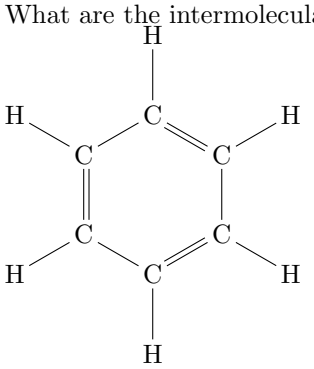
Describe the photoelectric effect.

Problem 23

List HCOOH, H_2S, and Ar in order of increasing intermolecular forces.

Problem 24

What are the intermolecular forces for this molecule:



Problem 25

Which of the following will require the greatest energy input to separate the ions?
(a) MgI_2
(b) MgF_2
(c) $MgCl_2$
(d) $MgBr_2$

Problem 26

Why does I_2 have a higher boiling point than Cl_2?

Problem 27

Is CO_2 polar? Why?

4 Unit 4: Chemical Reactions

Problem 28

Balance this reaction: $C_5H_{10} + O_2 \longrightarrow CO_2 + H_2O$

Problem 29

Balance this redox reaction: $MnO_4{}^- + I^- \longrightarrow I_2 + Mn^{2+}$

Problem 30

Aqueous $FeCl_3$ reacts with KOH to produce a solid precipitate of $Fe(OH)_3$ and aqueous KCl. What is the balanced net ionic equation?

Problem 31

What is the difference between physical changes and chemical changes?

Problem 32

H_2O and Fe are reacted according to the reaction below. There was initially $36.0g$ H_2O and $67.0g$ Fe. What is the limiting reactant, how much of the excess reactant will remain, and how much iron oxide is produced?
$3\,Fe\,(s) + 4\,H_2O\,(g) \longrightarrow Fe_3O_4(s)\,4\,H_2(g)$

Problem 33

A $56kg$ sample of CO and $6.0kg$ sample of H_2 are combined into a closed vessel.
$CO\,(g) + 2\,H_2(g) \longrightarrow CH_3OH\,(g)$
How many moles of $CH_3OH\,(g)$ have been produced?

Problem 34

Balance this reaction:
$Al\,(s) + O_2(g) \longrightarrow Al_2O_3$

Problem 35

Balance this reaction:
$V + O_2 \longrightarrow V_2O_5$

Problem 36

Balance this reaction:
$C_6H_{12}O_6 + O_2 \longrightarrow CO_2 + H_2O$

Problem 37

Balance this reaction:
$Mg + O_2 \longrightarrow MgO$

5 Unit 5: Kinetics

Problem 38

For this reaction:
$CH_4(g) + 2\,O_2(g) \longrightarrow CO_2(g) + 2\,H_2O(g)$
What would be rate be in terms of each reactant and product.
CH_4 rate =
O_2 rate =
CO_2 rate =
H_2O rate =

Problem 39

If the rate of dissapearance of CH_4 equals $5.0\frac{M}{s}$ for the above reaction, what is the rate of appearance of H_2O?

Problem 40

For the above reaction, what is the reaction rate if O_2 decreases from $0.1M$ to $0.04M$ in $125ms$?

Problem 41

$A\,(aq) + 2\,B\,(aq) \longrightarrow$ Products

Experiment	$[A]_0$	$[B]_0$	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 42

N_2O_5 decomposes by a 1st order reaction with $k = 4.80 \times 10^{-4}\frac{1}{s}$. What is the concentration of N_2O_5 after 825 seconds if the intial concentration is $0.0165M$? What is the half-life for this reaction?

Problem 43

This problem relates to problem 44 as well
The reaction $2\,C_4H_6(g) \longrightarrow C_8H_{12}(g)$ is a 2nd order reaction with $k = 4.0 \times 10^{-4}\frac{1}{Ms}$. If the initial concentration of C_4H_6 is $0.100M$ what is the concentration after 6 days?

Problem 44

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

Problem 45

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

$$\begin{aligned} &\mathrm{H_2O_2 + I^- \longrightarrow H_2O + IO^-} \quad k_1\,(\text{slow}) \\ &\mathrm{IO^- + H_2O_2 \longrightarrow H_2O + O_2 + I^-} \quad k_2\,(\text{fast}) \end{aligned}$$

Also identify catalysts and intermediates.

Problem 46

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

$$\begin{aligned} &\mathrm{2\,NO \rightleftharpoons N_2O_2} \quad \text{(Fast equilibrium step)} \\ &\mathrm{N_2O_2 + H_2 \longrightarrow H_2O + N_2O} \quad \text{(slow)} \\ &\mathrm{N_2O + H_2 \longrightarrow N_2 + H_2O} \quad \text{(fast)} \end{aligned}$$

6 Unit 6: Thermodynamics

Problem 47

It takes 1.8×10^{-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 48

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

Problem 49

How much heat energy is required to vaporize 5.0 liters of $\mathrm{H_2O\,(l)}$ where the heat of vaporization of water is $40.72\frac{kJ}{mol}$.

Problem 50

Given these chemical equations
$C_2H_2(g) + 2\,H_2(g) \longrightarrow C_2H_6(g) \quad \Delta H = -311kJ$
$C_2H_4(g) + H_2(g) \longrightarrow C_2H_6(g) \quad \Delta H = -136kJ$
Find the enthalpy change for
$C_2H_2(g) + H_2(g) \longrightarrow C_2H_6(g)$

Problem 51

For $C_2H_5OH(l) + 2\,O_2(g) \longrightarrow 2\,CO_2(g) + 2\,H_2O(l) \quad \Delta H = -1371kJ$. If $1.5mol$ of oxygen is used, how much energy is released?

Problem 52

When temperature increases, does entropy increase or decrease?

Problem 53

If the standard entropies for $H_2O(g)$, $H_2(g)$, and O_2 are 188.83, 130.58, and 205.0 respectively, what is the entropy change for $2\,H_2O(g) \longrightarrow 2\,H_2(g) + O_2(g)$?

Problem 54

What is $\Delta S_{universe}$ for the equation $CH_4(g) + 2\,O_2(g) \rightleftharpoons CO_2(g) + 2\,H_2O(g)$ where $\Delta H = -802.2\frac{kJ}{mol}$. Use the standard entropy values above and note that $S^\circ = 213.7$ and 186.1 for $CO_2(g)$ and $CH_4(g)$ respectively.

Problem 55

For $N_2(g) + 2\,H_2(g) \rightleftharpoons 2\,NH_3(g)$ where $\Delta H = -91.8kJ$ and $\Delta S^\circ = -197.3\frac{J}{K}$. Calculate ΔG° at $1000K$

Problem 56

For $2\,H_2O(g) \rightleftharpoons 2\,H_2(g) + O_2(g) \quad \Delta H^\circ = 483.6kJ$. Will the reaction form more or less product when temperature is increased.

7 Unit 7: Equilibrium

Problem 57

What is the concentration equilibrium constant for the reaction $CO(g) + 3\,H_2(g) \rightleftharpoons CH_4(g) + H_2O(g)$

Problem 58

If $K_c = 3.91$ at $1200K$, Will the reactants shift towards products, reactants, or stay the same if the reaction mixture contains $[CO] = 0.0200M$, $[H_2] = 0.0200M$, $[CH_4] = 0.00100M$, and $[H_2O] = 0.00100M$?

Problem 59

For this chemical reaction $2\,CH_4(g) \rightleftharpoons C_2H_2(g) + 3\,H_2(g)$, $K_p = 2.0 \times 10^{-6}$. $14atm$ of methane gas is put into the reaction vessel. What is the expected partial pressure of $C_2H_2(g)$ at equilibrium.

Problem 60

For this reaction $NH_4HS(s) \rightleftharpoons NH_3(g) + H_2S(g)$, $K_c = 0.16$. What is the molar concentration of each product if $250g$ of ammonium hydrogen sulfide is introduced into a $2.0L$ flask and allowed to reach equilibrium.

Problem 61

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

Problem 62

What is the solubility of $Ca_3(PO_4)_2$ in water at $25°C$ in where $K_{sp} = 1.2 \times 10^{-29}$.

Problem 63

$15mg$ of CaF_2 dissolves in $1.00L$ of water at $25°C$. What is K_{sp} for CaF_2 at this temperature?

Problem 64

What is the molar concentration of OH^- in an aqueous $1.3M$ HCl solution at $24°C$?

Problem 65

What is the pH of an aqueous solution of $0.050M$ HNO_3 solution at $25°C$?

Problem 66

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

8 Unit 8: Acids and Bases

Problem 67

Calculate the pH of a solution that is $0.5M$ CH_3COOH and $0.10M$ KCH_3COO.

Problem 68

Calculate the pH of a solution that is $0.10M$ CH_3COOH and $0.50M$ KCH_3COO.

Problem 69

Which of the following buffer systems would be the best choice for preparing a $pH = 4.10$ buffer solution. (a) $HNO_2/NaNO_2$ $\quad K_a = 7.1 \times 10^{-4}$
(b) $HCOOH/KHCOO$ $\quad K_a = 1.8 \times 10^{-4}$
(b) C_6H_5COOH/NaC_6H_5COO $\quad K_a = 6.3 \times 10^{-5}$

Problem 70

Will $0.2mol NH_3$ and $0.2mol NH_4Cl$ be a buffer solution?

Problem 71

Will $0.2mol CH_3COOH$ and $0.1mol NaOH$ be a buffer solution?

Problem 72

A $0.10M$ weak acid solution has a $pH = 3.7$. What is the percent ionization of the acid in this solution?

Problem 73

Why is HF weak but HCl is a strong acid?

Problem 74

Why is $HClO_4$ a strong acid but $HClO_2$ a weak acid?

Problem 75

What is the conjugate base of HSO_4^-?

Problem 76

What is the concentration of the hydroxide ion in pure water at $25°C$?

9 Unit 9: Applications of Thermodynamics

Problem 77

For this reaction, which element is oxidized or reduced at the anode.
$2\,\mathrm{NaCl(l)} \longrightarrow 2\,\mathrm{Na(l)} + \mathrm{Cl_2(g)}$

Problem 78

For the reaction $2\,\mathrm{Al^{3+}(aq)} + 3\,\mathrm{Mg(s)} \longrightarrow 2\,\mathrm{Al(s)} + 3\,\mathrm{Mg^{2+}(aq)}$. What are the half reactions?

Problem 79

Using the chemical reaction above:
If $E^\circ = 0.71V$ what is the cell potential if all the reactants are in their standard states except $\mathrm{Al^{3+}}$ which is present at $0.010M$?

Problem 80

Using the chemical reaction above:
What is the change in mass of the alumnimum electrode if this cell discharges for $100.0s$ with a current of $0.1A$?