Chapters 2 & 3: Atoms, Elements, Compounds, Mole

1. How many moles of oxygen atoms are present in one mole of aluminum sulfate, $Al_2(SO_4)_3$?

   A) 4
   B) 8
   C) 12
   D) 7.23 x 10^{24}
   E) 4.82 x 10^{24}

2. How many protons, neutrons, and electrons are in one ion of $^{36}S^{2-}$?

   A) 16 protons, 20 neutrons, and 18 electrons.
   B) 20 protons, 16 neutrons, and 16 electrons.
   C) 16 protons, 20 neutrons, and 14 electrons.
   D) 16 protons, 20 neutrons, and 16 electrons.
   E) 0 protons, 36 neutrons, and 18 electrons.

3. Which two elements are likely to form an ionic compound with the formula M_3X?

   A)Li and I
   B) Na and N
   C) Al and Br
   D) Ca and P
   E) K and O

4. Which compound is named *correctly*?

   A) CaO – Calcium (II) monoxide
   B) P_2O_5 – Diphosphorus pentoxide
   C) Al_2S_3 – Dialuminum trusulfide
   D) PbI_4 – Lead iodide
   E) H_2S – Sulfuric Acid

5. Determine the molecular formula of a compound that has a molecular weight of 183 g/mol and an empirical formula of $C_2H_5O_2$.

   A) $C_3H_7O_3$
   B) $C_6H_{15}O_6$
   C) $C_4H_{10}O_4$
   D) $C_2H_5O_2$
   E) $C_8H_{20}O_8$

CHEM 1310 Review: **Reactions, Solutions, & Stoichiometry**
Steps and **Answer Key**

1. Predict the products of the following reactions. Include the phase of each product. If there is no driving force for the reaction, write NR.

a. 3 Pb(II)$(CH_3COO)_2$ (aq) + 2 Na_3PO_4 (aq) -> Pb(II)$_3(PO_4)_2$ (s) + 6 $NaCH_3COO$ (aq)

b. $AgNO_2$ (aq) + NaCl (aq) -> AgCl (s) + $NaNO_2$ (aq)

c. NH_4OH (aq) + NaCl (aq) -> No reaction; both products are soluble

d. BaI_2 (aq) + $MgSO_4$ (aq) -> $BaSO_4$ (s) + MgI_2 (aq)

2. Calcium hydroxide is formed from the reaction of calcium oxide with water. What mass of calcium hydroxide can be produced from a mixture of 25.0 g of calcium oxide and 12.0 g of water? Identify limiting and excess reagents, calculate the mass (in grams) of excess reagent remaining.

i. Write out the reaction:

CaO (s) + H_2O (l) -> $Ca(OH)_2$ (s)

ii. Determine moles of reactants

$$\frac{25.0\ g\ CaO}{56.0774\frac{g}{mol}CaO} = 0.446\ mol\ CaO$$

$$\frac{12.0\ g\ H_2O}{18.015\frac{g}{mol}H_2O} = 0.666\ mol\ H_2O$$

iii. Use stoichiometric ratios to determine limiting reagent

Since there is a 1:1 ratio between both reactants and the single product, the reactant with the smaller number of moles (CaO) is the limiting reagent.

iv. Determine moles, mass of product from moles of limiting reagent

Calcium oxide is the limiting reagent; the number of moles of calcium hydroxide formed is the same as the number of moles of calcium oxide used in the reaction.

mol $Ca(OH)_2$ = mol CaO = 0.446 mol

The mass of calcium hydroxide formed can then be determined using the molar mass of the molecule:

$$0.446\ mol\ Ca(OH)_2 * 74.093\frac{g}{mol}Ca(OH)_2 = 33.1\ g\ Ca(OH)_2$$

v. Determine moles, mass of excess reagent remaining from moles of limiting reagent

If 0.466 moles of $Ca(OH)_2$ are formed, than 0.466 moles of H_2O, the limiting reagent, were consumed. The remaining mass of the limiting reagent is then:

$$0.666\ mol\ H_2O - 0.466\ mol\ H_2O = 0.200\ mol\ H_2O\ remaining$$

$$0.200\ mol\ H_2O * 18.015\frac{g}{mol}\ H_2O = 3.6\ g\ H_2O\ remaining$$

3. 92 g of sulfur hexafloride is produced from the reaction of sulfur in excess fluorine. If this corresponds to an 18% yield, what mass of sulfur was used for the reaction? Hint: Determine the theoretical yield of sulfur hexafloride.

$$S\ (s) + 3\ F_2\ (g) \rightarrow SF_6\ (g)$$

i. The mass of the product is given, as well as a corresponding percent yield. First, find the theoretical yield of sulfur hexafloride.

$$\frac{92\ g}{theoretical\ yield} = \frac{18\%}{100\%}$$

$$theoretical\ yield = \frac{92\ g}{0.18} = 511.11\ g\ SF_6$$

ii. With the theoretical yield, the moles of product for a 100% yield can be determined. This value can be used with the molar ratios of the reaction, given in the problem, to determine the moles of reactant.

$$\frac{511.11\ g\ SF_6}{146.055 \frac{g}{mol} SF_6} = 3.50\ mol\ SF_6$$

$$1\ mol\ SF_6 = 1\ mol\ S$$

iii. Finally, the mass of sulfur used for the reaction can be determined.

$$3.50\ mol\ S * 23.065 \frac{g}{mol} S = 112.2\ g\ S$$

4. What is the minimum volume of 1.1 M NaOH that must be reacted with excess chorine gas to yield 2.2 grams of sodium hypochorite?

$$2\ NaOH\ (aq) + Cl_2\ (g) \rightarrow NaClO\ (aq) + NaCl\ (aq) + H_2O\ (l)$$

i. Balance the given reaction!

ii. This problem gives the desired yield: 2.2 g of NaClO. First, find the number of moles of NaClO desired.

$$\frac{2.2\ g\ NaClO}{74.4422 \frac{g}{mol} NaClO} = 0.0296\ mol\ NaClO$$

iii. With a 2:1 stoichiometric ratio, the number of moles of NaOH required for the reaction is twice the number of moles of NaClO desired.

mol NaOH = 2 * mol NaClO = 0.0592 mol NaOH

iv. Finally, use the number of moles of NaOH to find the volume of 1.1 M solution that must be reacted.

$$\frac{0.0592\ mol\ NaOH}{x\ L} = 1.1\ M\ NaOH$$

$$\frac{0.0296\ mol}{1.1\ M} = 0.0537\ L = 53.7\ mL\ solution$$

5. Calcium chloride is reacted with silver nitrate.

a. Write the balanced reaction, and net ionic equations. Include the phase of each product.

Full reaction:

$Ca(Cl)_2$ (aq) + 2 $AgNO_3$ (aq) -> $Ca(NO_3)_2$ (aq) + 2 AgCl (s)

Net ionic equation:

2 Cl^- (aq) + 2 Ag^+ (aq) -> 2 AgCl (s)

b. If exactly 1.4 g of solid is formed, what mass of each reactant was used?

i. Determine moles of AgCl formed:

$$\frac{1.4\ g\ AgCl}{143.321\frac{g}{mol}AgCl} = 0.0098\ mol\ AgCl$$

ii. Using stoichiometric ratios, determine moles of reactants:

2 mol AgCl = 1 mol $Ca(Cl)_2$

0.0098 mol AgCl = 0.0049 mol $Ca(Cl)_2$

2 mol AgCl = 2 mol $AgNO_3$

0.0098 mol AgCl = 0.0098 mol $AgNO_3$

iii. Determine mass of reactants used:

$$0.0049\ mol\ Ca(Cl)_2 * 110.984\frac{g}{mol}Ca(Cl)_2 = 0.542\ g\ Ca(Cl)_2$$

$$0.0098\ mol\ AgNO_3 * 169.873\frac{g}{mol}AgNO_3 = 1.66\ g\ AgNO_3$$

c. If 2.0 mL of each reactant was used, what are the molarities of the calcium chloride and silver nitrate solutions?

The molarity of each solution can be determined as the number of moles of reactant over the liters of product used:

$$\frac{0.0049\ mol\ Ca(Cl)_2}{2.0\ mL * \frac{1\ L}{1000\ mL}} = 2.44\ M\ Ca(Cl)_2$$

$$\frac{0.0098\ mol\ AgNO_3}{2.0\ mL * \frac{1\ L}{1000\ mL}} = 4.88\ M\ AgNO_3$$

e. If 2.0 mL of 1.2 M calcium chloride is reacted with excess silver nitrate, what is the theoretical yield of the solid product?

i. Determine moles of calcium chloride used:

$$\frac{x\ mol\ Ca(Cl)_2}{2.0\ mL * \frac{1\ L}{1000\ mL}} = 1.2\ M\ Ca(Cl)_2$$

$$1.2\ M * 0.002\ L = 0.0024\ mol\ Ca(Cl)_2$$

ii. Using stoichiometric ratios, determine moles of the product:

$$1 \text{ mol } Ca(Cl)_2 = 2 \text{ mol } AgCl$$

$$0.0024 \text{ mol } Ca(Cl)_2 = 0.0048 \text{ mol } AgCl$$

iii. Finally, convert from moles to mass:

$$0.0048\ mol\ AgCl * 143.321 \frac{g}{mol} AgCl = 0.69\ g\ AgCl$$

6. What is the difference between a strong, a weak, and a nonelectrolyte? Give an example of each.

A strong electrolyte dissociates completely in water. These are strong acids, strong bases, and soluble salts (ex sodium choride).
A weak electrolyte dissociates only a small amount in water (usually less than 10%). These are weak acids and weak bases (ex acetic acid).
A nonelectrolyte does not dissociate in water. These are covalent molecules (ex sugar).

7. If 100.0 mL of acetic acid is titrated to equilibrium with 10.0 mL of 1 M KOH, what is the concentration (in units of molarity) of the acetic acid solution?

i. Write out the reaction:

$$CH_3COOH\ (aq) + KOH\ (aq) \rightarrow KCH_3COO\ (aq) + H_2O$$

ii. At equilibrium, with a 1:1 stoichiometric ratio, the number of moles of KOH titrated is the same as the number of moles of acetic acid in the original solution.

$$\frac{x\ mol\ KOH}{10.0\ mL * \frac{1\ L}{1000\ mL}} = 1\ M\ KOH$$

$$mol\ acetic\ acid = mol\ KOH = 1\ M * 0.01\ L = 0.01\ mol$$

iii. The concentration of the acetic acid solution can then be determined as moles / volume:

$$\frac{0.01\ mol\ acetic\ acid}{100.0\ mL * \frac{1\ L}{1000\ mL}} = 0.1\ M\ acetic\ acid$$

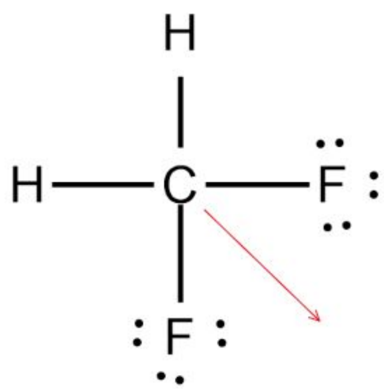
CHEM 1310 Reading Day
Chapters 7 and 8: *Gases* and *The Quantum Model of the Atom*
Answers

1. 9.65 atm
2. 5.0×10^{22} photons. Infrared radiation.
3. (a) 3d (b) 1s (c) 4f
4. (a) [He] $2s^2 2p^5$ (b) [Ar] $4s^2 3d^2$ (c) [Ne] $3s^2 3p^2$
5. a

CHEM 1310 Reading Day
Chapters 9, 10, and 11: *Periodicity and Ionic Bonding*, *Covalent Bonding*, and *Molecular Shape and Bonding Theories*
Answers

1. Na^+

2.

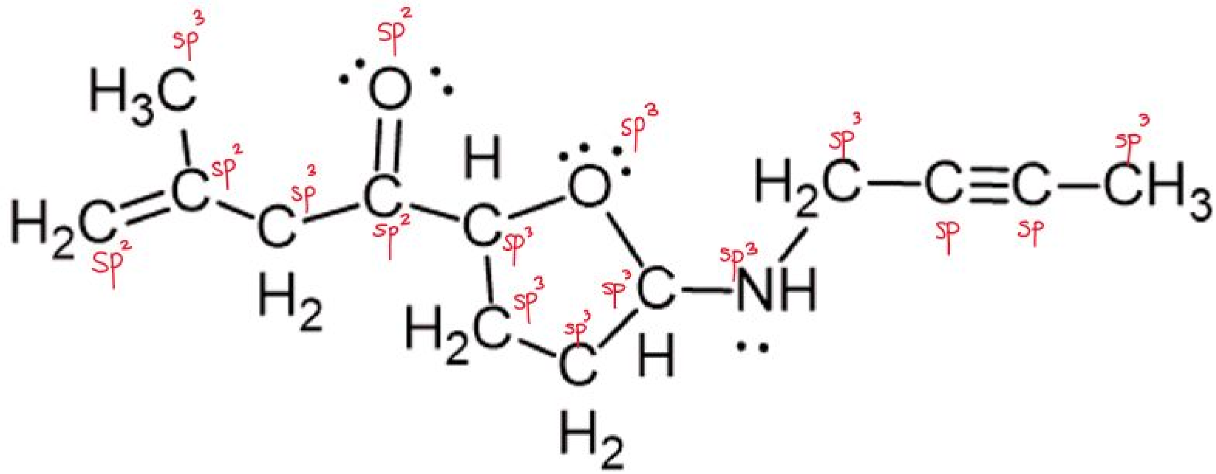


tetrahedral

3.

Molecule	Electron Geometry	Molecular Geometry	Bond Angle	Polar?
ClO^-	Linear	Linear	180	Yes
KrF_2	Trigonal bipyramidal	linear	180	No
XeF_3^+	Trigonal bipyramidal	T-shaped	< 90, < 180	Yes
NH_3Cl^+	Tetrahedral	Tetrahedral	109.5	Yes

5.



35 sigma bonds, 4 pi bonds

Ch 6 & 18: Thermochemistry and Chemical Thermodynamics

1. $HCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + HNO3(aq)$

$q_{rxn} = -q_{sol}$

=-(50ml+50ml)*1g/ml*4.184J/(g*C)*(25.10C-24.30C)

=-334.72J

$n_{HCl} = n_{AgNO3}$=.05L*0.1mol/L=0.005mol

ΔH=q/mol = -334.72J/0.005mol =66.944 kJ/mol

2. Calculate Δ*H* for the reaction $P_4O_{10}(s) + 6PCl_5(g) \rightarrow 10Cl_3PO(g)$ given the information below:

rxn1: $P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$ Δ*H* = - 1225.6 kJ

rxn2: $P_4(s) + 5O_2(g) \rightarrow P_4O_{10}(s)$ Δ*H* = - 2967.3 kJ

rxn3: $PCl_3(g) + Cl_2(g) \rightarrow PCl_5(g)$ Δ*H* = -84.2 kJ

rxn4: $PCl_3(g) + \frac{1}{2} O_2(g) \rightarrow Cl_3PO(g)$ Δ*H* = -285.7 kJ

I want $P_4O_{10}(s)$ $PCl_5(g)$ as my reactant so I have to reverse 2 and 3 and I want 6 of PCl5 so I also have to multiply by 6 after reversing

I want 10 $Cl_3PO(g)$ as my product so have to multiply rxn 4 by 10

Reverse 2 + reverse 3*(6), keep 1 and multiply 4 by 10

rxn1: $P_4(s) + 6Cl_2(g) \rightarrow 4PCl_3(g)$ Δ*H* = - 1225.6 kJ

-1*rxn2: $P_4O_{10}(s) \rightarrow P_4(s) + 5O_2(g)$ Δ*H* = 2967.3 kJ

(-1)*6*rxn3: 6*$PCl_5(g)$ → 6*$PCl_3(g)$ + 6*$Cl_2(g)$ Δ*H* = 84.2 kJ*6

10*rxn4: 10* $PCl_3(g)$ + 10*½ $O_2(g)$ → 10*$Cl_3PO(g)$ Δ*H* =10*(-285.7 kJ)

ΔHtotal =- 1225.6 kJ+2967.3 kJ+ 84.2 kJ*6 +10*(-285.7 kJ)

For the following chemical reactions, predict the sign of *ΔS* for the system. Note that this

3.

A) $Fe(s) + 2HCl(g) \rightarrow FeCl_2(s) + H_2(g)$ *Δn<0→ΔS* <0

B) $3NO_2(g) + H_2O(l) \rightarrow 2HNO_3(l) + NO(g)$ *Δn<0→ΔS* <0

C) $2K(s) + Cl_2(g) \rightarrow 2KCl(s)$ *g→ s ΔS* <0

D) $Cl_2(g) + 2NO(g) \rightarrow 2ClNO(g)$ *Δn<0→ΔS* <0

E) $SiCl_4(g) \rightarrow Si(s) + 2Cl_2(g)$ s→g *ΔS*>0

4. Write a thermochemical reaction to represent the combustion of Fe(s) with oxygen gas to produce iron(III) oxide if D*H* for the reaction is -1652 kJ/mol.
How much heat is released when 10.0 g Fe and 3.00 g O_2 react? You may assume that the percentage yield for the reaction is 100%.

$4Fe+3O_2 \rightarrow 2\ Fe_2O_3 + 1652$

$$\frac{10\text{g Fe}}{55.85\text{ g/mol}} = .179\ mol\ Fe * \frac{-1652kJ}{4\ Mol\ Fe} = -73.95\ kJ$$
$$\frac{3\text{ g O}_2}{32\text{ g/mol}} = 0.09375\ mol\ O_2 * \frac{-1652kJ}{3\ Mol\ O_2} = -51.625\ kJ$$

O_2 is the limiting agent → heat released is 51.6 kJ

5. A 95.0 g sample of H_2O at 22$_o$C is added to a 55.0$_o$C sample of water. If the final temperature of the resulting water sample is 37$_o$C, then what mass of hot water was added?

95g*4.184J/(g*C)*(37-22)= - m*4.184J/(g*C)*(37-55)

1425=m*18

m =79g

1.

If the rate of formation of NH_3 under a given set of conditions is 0.35 M/s, then what is the rate of disappearance of H_2 under the same conditions?

$$N_2(g) + 3\ H_2(g) \rightleftharpoons 2\ NH_3(g)$$

A) 0.23 M/s
B) 0.35 M/s
C) 0.53 M/s
D) 0.70 M/s
E) 1.1 M/s

2.

A first-order reaction is 38.5% complete in 520 s. What is the value of the rate constant?

A) $1.83 \times 10^{-3}\ s^{-1}$

B) $9.35 \times 10^{-4}\ s^{-1}$

C) $3.07 \times 10^{-3}\ s^{-1}$

D) $1.18 \times 10^{-3}\ s^{-1}$

E) $1.20 \times 10^{-3}\ s^{-1}$

3.

'. Data collected in a laboratory experiment was used to create a graph of ln k versus 1/T (T in Kelvin). The slope of the resulting line is m. Which answer option represents the activation energy for the reaction used to collect the data?

A) E_a/R
B) $-E_a/R$
C) mR
D) $-m$R
E) ln A

4. $K_c = 0.00392$

Phosgene, $COCl_2$, was used as a chemical weapon during World War I and is currently used as a starting material for the synthesis of other chemical compounds. Phosgene decomposes into carbon monoxide and chlorine gas.

$$COCl_2(g) \rightleftharpoons CO(g) + Cl_2(g)$$

Suppose that 0.250 mol $COCl_2$ decomposes in a sealed 1.00 L container at 1000 K to give 0.0294 mol CO at equilibrium.

a. Determine the equilibrium constant for the decomposition of phosgene at 1000 K.

5.

a. Shift to the left
b. Shift to the right
c. Shift to the left

Consider the following equilibrium:

$$2\ NOCl(g) \rightleftharpoons Cl_2(g) + 2\ NO(g)$$

Determine the relative values of *Q* and *K* when the following changes are made to the system, and determine the direction in which the reaction shifts after these changes are made:

a. Increasing the concentration of Cl_2
b. Decreasing the concentration of NO
c. Removing NOCl from the system

CHEM 1310 Review Session – ANSWER KEY
Chapters 16 and 19 – Acid/Base and Electrochemistry

Answers

1. $[H_3O^+] = 2.5 \times 10^{-3}$ M, pH = 2.60
2. $K_a = 7.84 \times 10^{-7}$ M
3. 13.7mL
4. Redox:
   a. $5\ SO_3^{2-}{}_{(aq)} + 2\ MnO_4^-{}_{(aq)} + 6\ H^+{}_{(aq)} \rightarrow 5\ SO_4^{2-}{}_{(aq)} + 2\ Mn^{2+}{}_{(aq)} + 3\ H_2O_{(l)}$
   b. $2\ I^-{}_{(aq)} + 2\ NO_2^-{}_{(aq)} + 4\ H^+{}_{(aq)} \rightarrow I_{2\,(s)} + 2\ NO_{(g)} + 2\ H_2O_{(l)}$
   c. $Al_{(s)} + MnO_4^-{}_{(aq)} + 2\ H_2O_{(l)} \rightarrow MnO_{2\,(s)} + Al(OH)_4^-{}_{(aq)}$
5. Standard Cells
   a. E°cell = 1.97V, spontaneous
   b. E°cell = 0.55V, spontaneous
   c. E°cell = -0.40V, non-spontaneous

CHEM 1310 Reading Day
Chapters 12 and 13: *Liquids and Solids* and *Solutions*
Answers

1.
    a. $SiH_4 < HCl < H_2O$
    b. $F_2 < Cl_2 < Br_2$
    c. $CH_4 < C_2H_6 < C_3H_8$

2.
    a. Gas to solid to liquid
    b. Gas to liquid
    c. Gas to solid (to liquid, maybe)

3. 113.4 kJ

4. +29.0 kJ/mol