The Physical Setting:

Chemistry

Regents Review

Through

Example

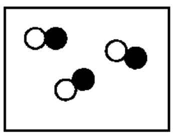
Matter & Energy / Atomic Structure / Kinetics Preview / Nuclear Chemistry - pages 2-8

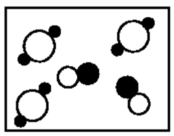
USE <u>TABLE S</u>	silver	______	Au	______	Ra	______		**USE <u>TABLE S</u>**
	cadmium	______	Hg	______	Hg	______		
	tin	______	Rn	______	Br	______		

Label, element/compound/mixture; homogeneous or heterogeneous; pure or impure substance for each.

NaCl (s), (l), (g) **NaCl (aq)** **NaCl mixed in a bag with sand.**

Describe what each of the boxes below portrays in terms of elements, compounds and mixtures.


A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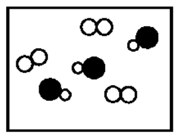
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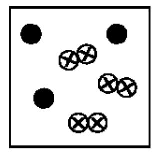
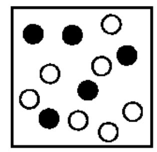
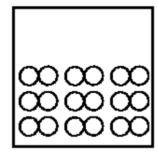

Sample 1


Sample 2


Sample 3

	Element	Compound	Pure Substance	Mixture
$NaCl_{(s)}$	_______	_______	_______	_______
$H_2O_{(l)}$	_______	_______	_______	_______
$NaCl_{(aq)}$	_______	_______	_______	_______
$HgNO_{3(aq)}$	_______	_______	_______	_______
$N_{2(g)}$	_______	_______	_______	_______
$Mg_{(s)}$	_______	_______	_______	_______
$H_2SO_{4(l)}$	_______	_______	_______	_______

Label each of the following below as a chemical or physical change?

______________Salt dissolving in water.

______________Melting iron.

______________Burning wood.

______________A liquid turns to a gas.

<u>**Tips for determining Exothermic and Endothermic reactions**</u>

Think of a chemical reaction (the actual equation) as a two room Building, which has an arrow that denotes where the exit door is.

A + B → C + D + Heat

There's the **EXIT** sign, and it's pointing right.

Now that we know where the **exit** door is, let's ***<u>label</u>*** the **exit** and **entrance** and stretch our imagination to pretend that the arrow also represents the wall that separates the two rooms in the building.

(<u>**EN**</u>t.) **A + B → C + D + Heat** (<u>**EX**</u>it)
wall

Now let's ask ourselves: In which room does the word <u>**Heat**</u> reside?
The room with the ***<u>EN</u>***trance or ***<u>EX</u>***it door.

(<u>**EN**</u>t.) **A + B → C + D + Heat** (<u>**EX**</u>it)
wall

Seems like ***<u>Heat</u>*** is in the *room* with the ***<u>EX</u>***it door…therefore we will say that the reaction is ***<u>Ex</u>***othermic.

$N_2(g) + 3H_2(g) \leftrightarrows 2NH_3(g) + 91.8\ kJ$

Based on the reaction above, supply the correct responses below.

For the ***Forward*** reaction (L→R), list terms that can be used to describe the forward reaction:

____

For the ***Reverse*** reaction (R→L), list terms that can be used to describe the reverse reaction:

____

Is the decomposition reaction (endothermic / exothermic)?
Is the formation reaction (endothermic / exothermic)?
In the decomposition reaction, is energy being (absorbed or released)?
In the synthesis reaction, is energy being (absorbed or released)?
Is the Heat of Reaction for formation (positive or negative)?
Is the Heat of Reaction for decomposition (positive or negative)?
In the formation reaction, which has more potential energy, the (reactants or products)?
In the decomposition reaction, which has more potential energy, the (reactants or products)?

What is the enthalpy / delta H / Heat of Reaction or
ΔH for the production of 1 mole and 4 moles of NH_3? 1 mole = ____________

4 moles = ____________

How much energy is required for the synthesis of .5 mole of NH_3? ____________________

From the previous question, what is a better word that could replace the word "required?"

What is the ΔH for the decomposition of 2 moles of NH_3? ____________________

Draw and label the 6 points of a potential energy diagram for the
endothermic and exothermic reactions of the above chemical reaction.

Endothermic

POT ENERGY

Exothermic

POT ENERGY

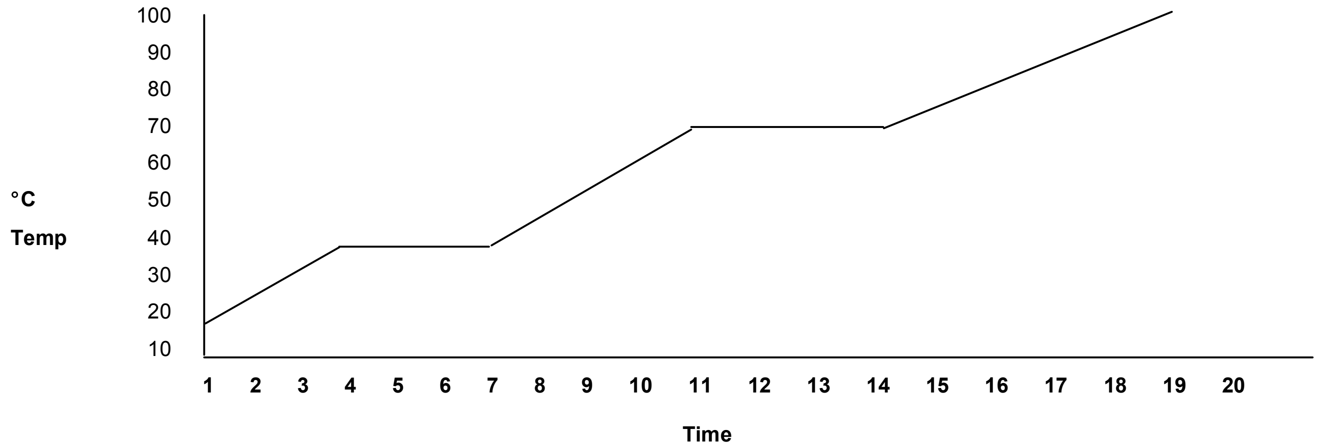
1. ____________________ 2. ____________________

3. ____________________ 4. ____________________

5. ____________________ 6. ____________________

Graph and Label this Heating Curve

Include: 1) Letters for each point of importance, 2) label phases of matter, 3) Label phase changes, 4) Melting point/ Freezing point, 5) Boiling Point, 6) Heat of Fusion, 7) Heat of Vaporization 8) Heating or Cooling Curve, 9) Heat of Condensation, 10) Heat of Crystallization



Time	Temp °C	Time	Temp °C	Time	Temp °C	Time	Temp °C
1	15 °C	6	39 °C	11	66°C	16	80 °C
2	23 °C	7	39 °C	12	66°C	17	87 °C
3	35 °C	8	45 °C	13	66°C	18	93 °C
4	39 °C	9	52 °C	14	66°C	19	100 °C
5	39 °C	10	59 °C	15	75°C		

What is the Melting Point temperature ________________ °C

What is the Boiling Point temperature ________________ °C

Is this an exothermic reaction or endothermic? __________

Which point could represent crystallization? _______ (Under what conditions?)

Which point represents the heat of fusion? __________________

Which point is pot. energy the most?___________ Kinetic energy? ________

What term is used to identify the process that is taking in this equation $I_{2\,(s)} \rightarrow I_{2\,(g)}$ Condensation Sublimation Melting Boiling

What other compound can accomplish the same process as noted above? ____________________

Table T
Important Formulas and Equations

Heat	$q = mC\Delta T$ $q = mH_f$ $q = mH_v$	q = heat m = mass C = specific heat capacity ΔT = change in temperature H_f = heat of fusion H_v = heat of vaporization
Temperature	K = °C + 273	K = kelvin °C = degrees Celsius

Table B
Physical Constants for Water

Heat of Fusion	334 J/g
Heat of Vaporization	2260 J/g
Specific Heat Capacity of H_2O (ℓ)	4.18 J/g•°C

What are the two fixed points on a thermometer in °C and K? _____°C and ____°C ______K and ____ K

Convert the following to Kelvin temperature and Celsius: a) 10°C b) 220K c) - 45°C d) 396K e) - 273°C

A liquid's freezing point is – 38 °C and its boiling point is 230 °C. How many Kelvins and degrees Celcius are there between the boiling point and freezing point of the liquid?

Kelvins ______________ Degrees Celsius ______________

If 20 grams of water is heated from 20°C to 60°C, the number of joules of heat energy absorbed is ______________________.

The temperature of 80 grams of water was raised to 35°C by the addition of 6270 joules of heat energy. What was the initial temperature of the water? __________.

A sample of water is heated from 282 K to 297 K by the addition of 3000 Joules of heat. What is the mass of the water? ___________________

If a 4.0 gram sample of water at 10°C absorbs 20 Joules of heat energy, the temperature of the sample will be raised by how many kelvins?______________

How much energy is required to covert 100g of H_2O(s) to H_2O(l)? _______________________

How much energy is released when 10 g of water vapor condenses?

Kinetic Theory of Gases

1. Because relatively great distances separate gas particles, volume occupied by the particles themselves are negligible.
2. Gases contain particles (usually molecules or atoms) that are in constant, random, straight-line motion.
3. Gas particles collide with each other against the walls of its container, transferring energy, with no loss, yet they are elastic.
4. Gas particles do not attract each other.

Above is the Kinetic Theory of Gases. Which two cannot exist in the Real World? ______, _______

Under what conditions will a gas act ideally? [Give the condition(s)] Explain through an example.

A gas has a volume of 2000 mL at –253 °C and a pressure of 101.3 kPa . What will be the new volume when the temperature is changed to – 233 °C and the pressure is changed to 198.5 kPa? **Is this a Charles' Law, Boyles' Law or Combined Gas Law problem?**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

P = pressure
V = volume
T = temperature (K)

A 6.3 liter sample of a gas is at STP. When the temp is raised to 9°C , pressure remaining constant, what will be the new volume of the gas? **Is this a Charles' Law, Boyles' Law or Combined Gas Law problem?**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

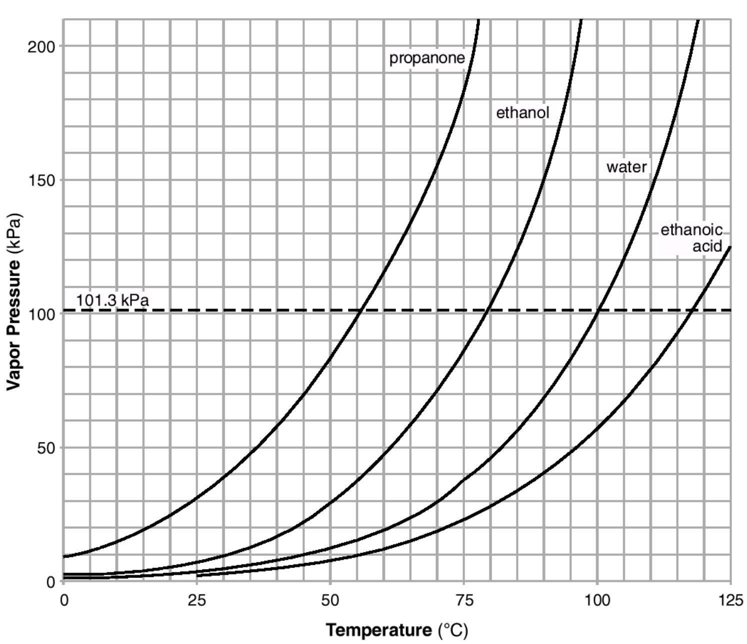
P = pressure
V = volume
T = temperature (K)

The pressure exerted on 800mL of a gas is decreased from 300 kPa to 198 kPa. What is the new volume of the gas if the temp remains constant? **Is this a Charles' Law, Boyles' Law or Combined Gas Law problem?**

$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

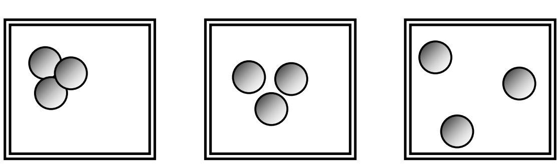
P = pressure
V = volume
T = temperature (K)

Table H
Vapor Pressure of Four Liquids



1. Pure water will boil at 70°C in a closed system when the vapor pressure in the system is _________.
2. As kinetic energy increases, vapor pressure of a liquid _______________.
3. Which of the following four liquids in Table H vaporizes most easily? ____________
4. Which substance in Table H has the strongest and weakest intermolecular forces of attraction? Strongest ____________ Weakest __________
5. Describe the difference between intermolecular forces of attraction between (s), (l), (g).

How do the diagrams below relate to intermolecular forces of attraction and (s), (l), (g).



What is the atomic # ___ What is the mass # ___

How many protons ___ How many neutrons ___

How many electrons ___ How many valence electrons are there ___

39.948 0
Ar
18
2-8-8

Write out the electrons configuration in the ground state. ________________________________

Write out the possible electrons configuration in the excited state.__________________________

What happens when an electron moves from a higher principle energy level to a lower energy level?

What principle energy level do the valence electrons reside on ___

What group # is this element a part of ___ What period ___

What kind of info does a group # and period # reveal ___

What is the difference between Ar-40 and Ar-37?

$^{40}Ar_{18}$	$^{37}Ar_{18}$
#p ___	#p ___
#n ___	#n ___
#e ___	#e ___

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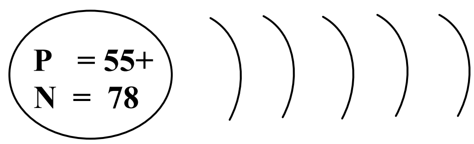
e- = 54⁻



Net Charge
# of protons = +___
# of electrons = -___

Total Net Charge =

Write out the electron configuration for the sample above_____________________

Complete the shells above with the appropriate number for the electron configuration.

What is the identity of the sample above? **Be Careful, calculate the Net Charge first** _________________

What other element does this sample share its electron configuration with? ___________

Is this element now considered stable? _________ Why?________________________________

Write out the electron, orbital and electron-dot symbol configuration for Mg atom .

Electron-Dot Symbol
Mg

Electron configuration ___________________________________

Write out the kernel __________________________

Valence Level = _______ # of Valence e- = _____ Group number = _____ Period = _______

Write out the electron, orbital and electron-dot symbol configuration for Cl atom.

Electron-Dot Symbol
Cl

Electron configuration ___________________________________

Write out the kernel _____________________________________

Valence Level = _______ # of Valence e- = _____ Group number = _____ Period = _______

Write out the electron, orbital and electron-dot symbol configuration for Cl^{+3} ion .

Electron-Dot Symbol
Cl

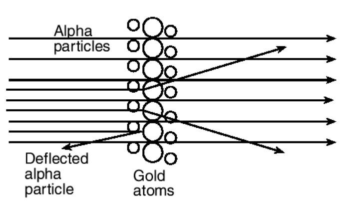
Electron configuration ___________________________________

Write out the kernel _____________________________________

Valence Level = _______ # of Valence e- = _____ Group number = _____ Period = _______

In Rutherford's experiment, most of the alpha particles passed through the gold foil. Which observation verifies this? (Circle one)

Thicker gold foil scatters more. Most pass through with little or no deflection. The paths are hyperbolic. The scattering angle is related to the atomic number.



One model of the atom states that atoms are tiny particles composed of a uniform mixture of positive and negative charges. Scientists conducted an experiment where alpha particles were aimed at a thin layer of gold atoms.

Most of the alpha particles passed directly through the gold atoms. A few alpha particles were deflected from their straight-line paths. An illustration of the experiment is shown below.

Radioactivity – the spontaneous release of energy by a nucleus.

A. **Natural radioactivity** occurs in elements that are unstable. These elements have atomic numbers **above 83** on the periodic table. They undergo **spontaneous decay**.

Natural Transmutation

Table O
Symbols Used in Nuclear Chemistry

Name	Notation	Symbol
alpha particle	${}^{4}_{2}He$ or ${}^{4}_{2}\alpha$	α
beta particle (electron)	${}^{0}_{-1}e$ or ${}^{0}_{-1}\beta$	β^-
gamma radiation	${}^{0}_{0}\gamma$	γ
neutron	${}^{1}_{0}n$	n
proton	${}^{1}_{1}H$ or ${}^{1}_{1}p$	p
positron	${}^{0}_{+1}e$ or ${}^{0}_{+1}\beta$	β^+

1. ***Alpha decay*** – release an alpha particle, which is a He nucleus (He). The mass in reaction will decrease by 4 and the atomic # by 2.

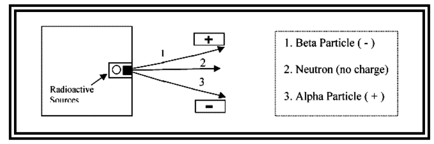
$${}^{226}_{88}Ra \rightarrow {}^{222}_{86}Rn + {}^{4}_{2}He$$

2. ***Beta decay*** – is the release of a beta particle, which is a high speed electron. The mass doesn't change but the atomic # increases by 1.

$${}^{214}_{82}Pb \rightarrow {}^{214}_{83}Bi + {}^{o}_{-1}e$$

3. ***Gamma radiation*** is a loss of energy. The mass and the charge do not change.

$${}^{214}_{82}Pb \rightarrow {}^{214}_{82}Pb + Energy$$



Artificial Transmutation (Nuclear Equations):

With a proton: ${}_{1}H^{1} + {}_{4}Be^{9} \rightarrow {}_{3}Li^{6} + {}_{2}He^{4}$

With a neutron: ${}_{0}n^{1} + {}_{13}Al^{27} \rightarrow {}_{11}Na^{24} + {}_{2}He^{4}$

With an alpha particle: ${}_{13}Al^{27} + {}_{2}He^{4} \rightarrow {}_{15}P^{30} + {}_{0}n^{1}$

Fission Nuclear Reaction:

$${}_{0}n^{1} + {}_{92}U^{235} \rightarrow {}_{56}Ba^{142} + {}_{36}Kr^{91} + 3\ {}_{0}n^{1} + energy$$

Fusion Reaction

$${}_{1}H^{2} + {}_{1}H^{2} \rightarrow {}_{2}He^{4} + energy$$

B. **Half life** – is the time required for a sample to decay by ½. **Table N** is a list of selected half-lives.

Consider the radioactive isotope iodine-131, whose 1/2-life is 8 days.

If we had 16-milligrams of this isotope, it would decay over time as follows:

(16 days →) (24 days →) (32 days →)

8d 8d 8d 8d

16 mg → 8 mg → 4 mg → 2 mg → 1 mg

So, after 32 days of decay 1 milligram of iodine-131 remains unchanged.

What mass of iodine-131 (half life of 8 days) remains 32 days after a 100-gram sample of this isotope is obtained?

We have a **half-life of 8-days** and the time the problem gives us is **32 days**.

Let's do this part of the problem first… **Time allotted** = 32 days

Half-Life = 8 days so **32 / 8 = 4 total Half Lives.**

Fraction remaining = Draw 4 arrows, which represent each of the 4 Half Lives

→ → → → [then stat with the number 1]

1 → → → → [then proceed to halve each end results]

1 → **1/2** → **1/4** → **1/8** → **1/16** , BINGO 1/16 is your answer

----

1. The nuclide (atomic nucleus) ${}^{220}_{87}Fr$ undergoes alpha decay. **Write a balanced equation that illustrates this process**

.2. When a certain radioactive nuclide undergoes alpha decay, ${}^{218}_{84}Po$. is formed as a daughter nucleus. **Identify the parent nuclide**

3. The nuclide (atomic nucleus) ${}^{234}_{90}Th$ undergoes beta decay. **Write a balanced equation that illustrates this process**

.4. Write a balanced nuclear equation that shows how the daughter nucleus ${}^{14}N$ is produced by beta (-) decay

5. In the reaction:

$X + {}_{2}He^{4} \rightarrow {}_{15}P^{30} + {}_{0}n^{1}$ the nucleus represented by x is __________

6. In the reaction:

${}_{92}U^{238} + {}_{2}He^{4} \rightarrow X + {}_{0}n^{1}$ the nucleus represented by x is __________

7. In the reaction:

$X + {}_{1}H^{1} \rightarrow {}_{3}Li^{6} + {}_{2}He^{4}$ the nucleus represented by x is __________

8. What total mass of a 16-gram sample of cobalt-60 will remain unchanged after 15.9 years (use table H)?
1. 8.0 g **2.** 4.0 g **3.** 2.0 g **4.** 1.0 g

9. At the end of 24 days ¼ of an original sample of a radioactive element remains. What is the half-life of the element?
1. 12 days **2.** 6 days **3.** 48 days **4.** 14 days

10. What fraction of N-16 is left after 28.8 seconds?

Table N
Selected Radioisotopes

Nuclide	Half-Life	Decay Mode	Nuclide Name
^{198}Au	2.69 d	β^-	gold-198
^{14}C	5730 y	β^-	carbon-14
^{37}Ca	175 ms	β^+	calcium-37
^{60}Co	5.26 y	β^-	cobalt-60
^{137}Cs	30.23 y	β^-	cesium-137
^{53}Fe	8.51 min	β^+	iron-53
^{220}Fr	27.5 s	α	francium-220
^{3}H	12.26 y	β^-	hydrogen-3
^{131}I	8.07 d	β^-	iodine-131
^{37}K	1.23 s	β^+	potassium-37
^{42}K	12.4 h	β^-	potassium-42
^{85}Kr	10.76 y	β^-	krypton-85
^{16}N	7.2 s	β^-	nitrogen-16
^{19}Ne	17.2 s	β^+	neon-19
^{32}P	14.3 d	β^-	phosphorus-32
^{239}Pu	2.44×10^4 y	α	plutonium-239
^{226}Ra	1600 y	α	radium-226
^{222}Rn	3.82 d	α	radon-222
^{90}Sr	28.1 y	β^-	strontium-90
^{99}Tc	2.13×10^5 y	β^-	technetium-99
^{232}Th	1.4×10^{10} y	α	thorium-232
^{233}U	1.62×10^5 y	α	uranium-233
^{235}U	7.1×10^8 y	α	uranium-235
^{238}U	4.51×10^9 y	α	uranium-238

ms = milliseconds; s = seconds; min = minutes;
h = hours; d = days; y = years

Unit 3 Review – Bonding

Range of Electronegativity Difference	Bond Type
0 – 0.3	***Non polar Covalent***
0.4 – 1.6	***Polar Covalent***
Greater than or equal to 1.7	***Ionic***

	Formula	**Electro. Diff.**	**Bond type (non-polar, polar or ionic)**	**Type of molecule (dipole / not dipole)**	**Dashed Structure of Molecule Constructed**	**Electron Dot Structure of Molecule Constructed**	**Shape of Molecule (linear, tetrahedral, bent, pyramidal)**	**Symmetry (Symmetrical/non-symmetrical)**
Example # 1	H_2							
Example # 2	NaCl			na				
Example # 3	$MgCl_2$			na				
Example # 4	H_2O							
Example # 5	CO_2							
Example # 6	NH_3							
Example # 7	CCl_4							

Using Electronegativity differences, arrange the following four compounds in order of increasing ionic character: KBr, $AlCl_3$, Li_2O, NaI

Characteristics of types of bonds

Ionic Solids (ionic)

Molecular Substances (covalently bonded)

Network Solids (covalently bonded)

Metallic Bonding (neither)

Table E
Selected Polyatomic Ions

H_3O^+	hydronium	CrO_4^{2-}	chromate
Hg_2^{2+}	dimercury (I)	$Cr_2O_7^{2-}$	dichromate
NH_4^+	ammonium	MnO_4^-	permanganate
$C_2H_3O_2^-$ / CH_3COO^-	acetate	NO_2^-	nitrite
		NO_3^-	nitrate
CN^-	cyanide	O_2^{2-}	peroxide
CO_3^{2-}	carbonate	OH^-	hydroxide
HCO_3^-	hydrogen carbonate	PO_4^{3-}	phosphate
$C_2O_4^{2-}$	oxalate	SCN^-	thiocyanate
ClO^-	hypochlorite	SO_3^{2-}	sulfite
ClO_2^-	chlorite	SO_4^{2-}	sulfate
ClO_3^-	chlorate	HSO_4^-	hydrogen sulfate
ClO_4^-	perchlorate	$S_2O_3^{2-}$	thiosulfate

Write out the formula for **Iron (III) Oxide**

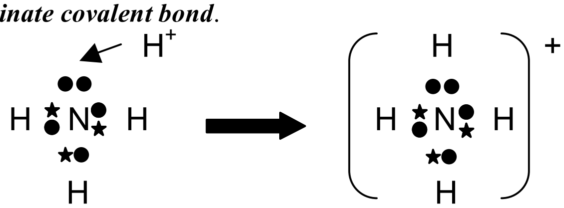
Write out the formula for **Aluminum Nitrite**.

What are the oxidation numbers of each of the elements in the compound **K_2CrO_4**?

Find the oxidation numbers of each of the following elements in each compound:

$Ca(NO_3)_2$ **HCO_3^-**

Using your understanding of bonding and atomic structure, plus the picture below, define the conditions that are characteristic of a ***coordinate covalent bond***.



BEFORE **AFTER** (*coordinate covalent bond*)

Answer:

Identify the following types of reactions as synthesis(direct combination), decomposition, single replacement, or double replacement.

____________________ $Al_2(SO_4)_3 + Ca(OH)_2 \rightarrow Al(OH)_3 + CaSO_4$

____________________ $2Mg + O_2 \rightarrow 2MgO$

____________________ $H_2 + Fe_3O_4 \rightarrow Fe + H_2O$

____________________ $Ag_2O \rightarrow 2Ag + O_2$

Balance these chemical equations!

$F_2 + H_2O \rightarrow HF + O_3$ **What is the sum of the coefficients? _____**

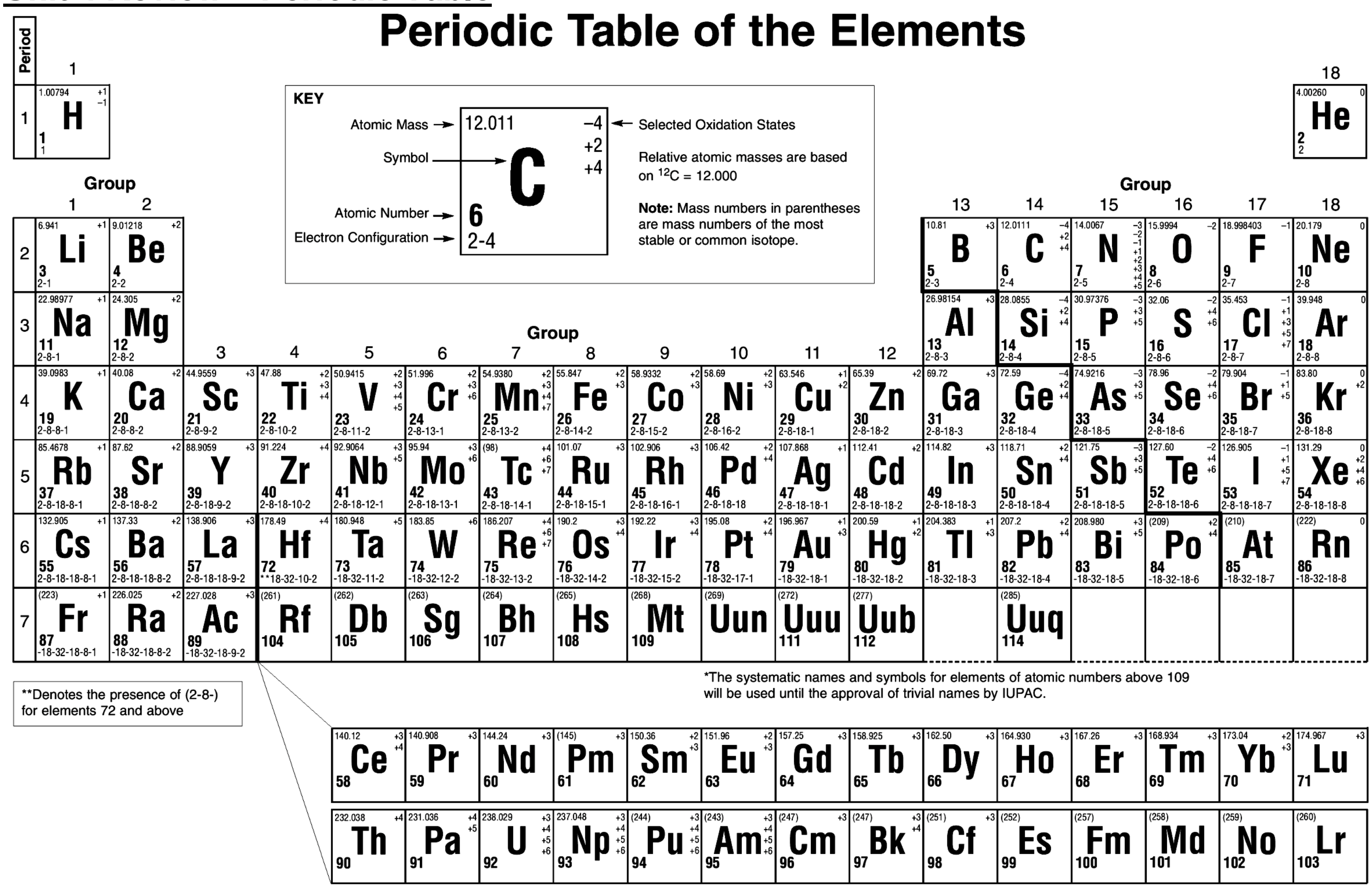
$Al + Pb(NO_3)_2 \rightarrow Al(NO_3)_3 + Pb$ **What is the sum of the coefficients? _____**

Complete each of the following reactions by **writing the correct formulas for the products in words and symbols**, **balance each equation**; then **identify the type of reaction** as synthesis, decomposition, single replacement, or double replacement.

Barium + Gold(III)Chloride →

Calcium Hydroxide + Potassium Nitrate →

Unit 4 Review – Periodic Table



NOTES

Table S
Properties of Selected Elements

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm³)	Atomic Radius (pm)
1	H	hydrogen	1312	2.1	14	20	0.00009	37
2	He	helium	2372	—	1	4	0.000179	32
3	Li	lithium	520	1.0	454	1620	0.534	155
4	Be	beryllium	900	1.6	1551	3243	1.8477	112
5	B	boron	801	2.0	2573	3931	2.340	98
6	C	carbon	1086	2.6	3820	5100	3.513	91
7	N	nitrogen	1402	3.0	63	77	0.00125	92
8	O	oxygen	1314	3.5	55	90	0.001429	65
9	F	fluorine	1681	4.0	54	85	0.001696	57
10	Ne	neon	2081	—	24	27	0.0009	51
11	Na	sodium	496	0.9	371	1156	0.971	190
12	Mg	magnesium	736	1.3	922	1363	1.738	160
13	Al	aluminum	578	1.6	934	2740	2.698	143
14	Si	silicon	787	1.9	1683	2628	2.329	132
15	P	phosphorus	1012	2.2	317	553	1.820	128
16	S	sulfur	1000	2.6	386	718	2.070	127
17	Cl	chlorine	1251	3.2	172	239	0.003214	97
18	Ar	argon	1521	—	84	87	0.001783	88
19	K	potassium	419	0.8	337	1047	0.862	235
20	Ca	calcium	590	1.0	1112	1757	1.550	197
21	Sc	scandium	633	1.4	1814	3104	2.989	162
22	Ti	titanium	659	1.5	1933	3580	4.540	145
23	V	vanadium	651	1.6	2160	3650	6.100	134
24	Cr	chromium	653	1.7	2130	2945	7.190	130
25	Mn	manganese	717	1.6	1517	2235	7.440	135
26	Fe	iron	762	1.8	1808	3023	7.874	126
27	Co	cobalt	760	1.9	1768	3143	8.900	125
28	Ni	nickel	737	1.9	1726	3005	8.902	124
29	Cu	copper	745	1.9	1357	2840	8.960	128
30	Zn	zinc	906	1.7	693	1180	7.133	138
31	Ga	gallium	579	1.8	303	2676	5.907	141
32	Ge	germanium	762	2.0	1211	3103	5.323	137
33	As	arsenic	944	2.2	1090	889	5.780	139
34	Se	selenium	941	2.6	490	958	4.790	140
35	Br	bromine	1140	3.0	266	332	3.122	112
36	Kr	krypton	1351	—	117	121	0.00375	103
37	Rb	rubidium	403	0.8	312	961	1.532	248
38	Sr	strontium	549	1.0	1042	1657	2.540	215
39	Y	yttrium	600	1.2	1795	3611	4.469	178
40	Zr	zirconium	640	1.3	2125	4650	6.506	160

Atomic Number	Symbol	Name	First Ionization Energy (kJ/mol)	Electro-negativity	Melting Point (K)	Boiling* Point (K)	Density** (g/cm³)	Atomic Radius (pm)
41	Nb	niobium	652	1.6	2741	5015	8.570	146
42	Mo	molybdenum	684	2.2	2890	4885	10.220	139
43	Tc	technetium	702	1.9	2445	5150	11.500	136
44	Ru	ruthenium	710	2.2	2583	4173	12.370	134
45	Rh	rhodium	720	2.3	2239	4000	12.410	134
46	Pd	palladium	804	2.2	1825	3413	12.020	137
47	Ag	silver	731	1.9	1235	2485	10.500	144
48	Cd	cadmium	868	1.7	594	1038	8.650	171
49	In	indium	558	1.8	429	2353	7.310	166
50	Sn	tin	709	2.0	505	2543	7.310	162
51	Sb	antimony	831	2.1	904	1908	6.691	159
52	Te	tellurium	869	2.1	723	1263	6.240	142
53	I	iodine	1008	2.7	387	458	4.930	132
54	Xe	xenon	1170	2.6	161	166	0.0059	124
55	Cs	cesium	376	0.8	302	952	1.873	267
56	Ba	barium	503	0.9	1002	1910	3.594	222
57	La	lanthanum	538	1.1	1194	3730	6.145	138
Elements 58–71 have been omitted.								
72	Hf	hafnium	659	1.3	2503	5470	13.310	167
73	Ta	tantalum	728	1.5	3269	5698	16.654	149
74	W	tungsten	759	2.4	3680	5930	19.300	141
75	Re	rhenium	756	1.9	3453	5900	21.020	137
76	Os	osmium	814	2.2	3327	5300	22.590	135
77	Ir	iridium	865	2.2	2683	4403	22.560	136
78	Pt	platinum	864	2.3	2045	4100	21.450	139
79	Au	gold	890	2.5	1338	3080	19.320	146
80	Hg	mercury	1007	2.0	234	630	13.546	160
81	Tl	thallium	589	2.0	577	1730	11.850	171
82	Pb	lead	716	2.3	601	2013	11.350	175
83	Bi	bismuth	703	2.0	545	1833	9.747	170
84	Po	polonium	812	2.0	527	1235	9.320	167
85	At	astatine	—	2.2	575	610	—	145
86	Rn	radon	1037	—	202	211	0.00973	134
87	Fr	francium	393	0.7	300	950	—	270
88	Ra	radium	—	0.9	973	1413	5.000	233
89	Ac	actinium	499	1.1	1320	3470	10.060	—
Elements 90 and above have been omitted.								

*Boiling point at standard pressure
**Density at STP

NOTES

Unit 5 Review – Mathematics of Chemistry (plus solutions)

1 mole of something = gram formula mass of an element/compound = 6.02×10^{23} (atoms / molecules) = 22.4 L of a gas at STP

Molecular (formula) Mass

1. What is the molecular (formula) mass of Na_2CO_3?

2. Find the formula mass of $CuSO_4$.

Gram Molecular (gram formula) Mass

1. What is the mass in grams of 3.5 moles of water?

1 mole of something = gram formula mass of an element/compound = 6.02×10^{23} (atoms / molecules) = 22.4 L of a gas at STP

2. What is the mass of 1.2×10^{24} molecules of O_2?

1 mole of something = gram formula mass of an element/compound = 6.02×10^{23} (atoms / molecules) = 22.4 L of a gas at STP

Mole Volume of a Gas

1. What is the mass of 56 liters of $CO_{2\,(g)}$ at STP?

1 mole of something = gram formula mass of an element/compound = 6.02×10^{23} (atoms / molecules) = 22.4 L of a gas at STP

2.What is the volume occupied by 3 moles of nitrogen gas (N_2) at STP?

1 mole of something = gram formula mass of an element/compound = 6.02×10^{23} (atoms / molecules) = 22.4 L of a gas at STP

Finding the Number of Moles

1. How many moles are present in 180 grams of NaOH?

1 mole of something = gram formula mass of an element/compound = 6.02×10^{23} (atoms / molecules) = 22.4 L of a gas at STP

STOICHIOMETRY

Problems Involving Formulas

1. What is the percentage composition by mass of the elements in sodium sulfate, Na_2SO_4?

2. What is the percentage of water by mass in sodium carbonate crystals, $Na_2CO_3 \bullet 5H_2O$?

Empirical Formulas

1. A compound has the empirical formula CH_2 & a molecular mass of 42. Its molecular formula is ___________

2. A sample of a compound contains 24 grams of carbon and 64 grams of oxygen. What is the empirical formula of this compound?

Problems Involving Equations

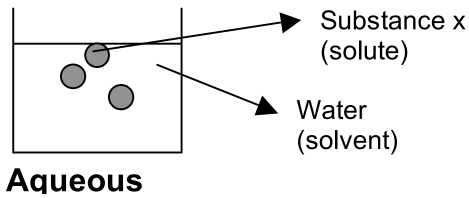
1. How many moles of water will be produced from the complete combustion of 3 moles of ethane?

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

2. $N_2 + 3H_2 \rightarrow 2NH_3$, how many moles of N_2 are needed to produce 5 moles of NH_3?

Solutions

A **solution** is a **homogeneous mixture** of two or more substances.
Solvent - the substance that is in the larger amount.
Solute- the substance that is in the smaller amount.
Aqueous Solutions- solutions in which water is the solvent.
Concentration- the quantity of solute in a given measure (volume or mass)



Saturated and Unsaturated Solutions

Let's say we're mixing table salt in water. The solution is:

Saturated – when the water will accept **no more** solute (salt), and any remaining salt drops to the bottom.
Supersaturated – when a solution prepared at a higher temp is cooled, the solute (like salt in water) fails to dropout of the solution. Eventually, the excess solute will leave the solution as it returns to its normal saturation point.)
Unsaturated- when the water will **still** accept more solute (salt) in the solution.

Solubility

- the quantity of solute (like salt) needed to ***just saturate*** a given amount of solvent (water)

The units for measuring solubility is: ***grams of solute per 100 grams of solvent***.

(ex. At 20°C, 38 grams of NaCl will just saturate 100 grams of H_2O. The solubility of NaCl at 20°C is ***38 grams NaCl per 100 grams H_2O.)***

The solubility of solids and liquids ***increase,*** while the solubility of gases ***decrease***, with increasing temperature.

Table G Solubility Curves

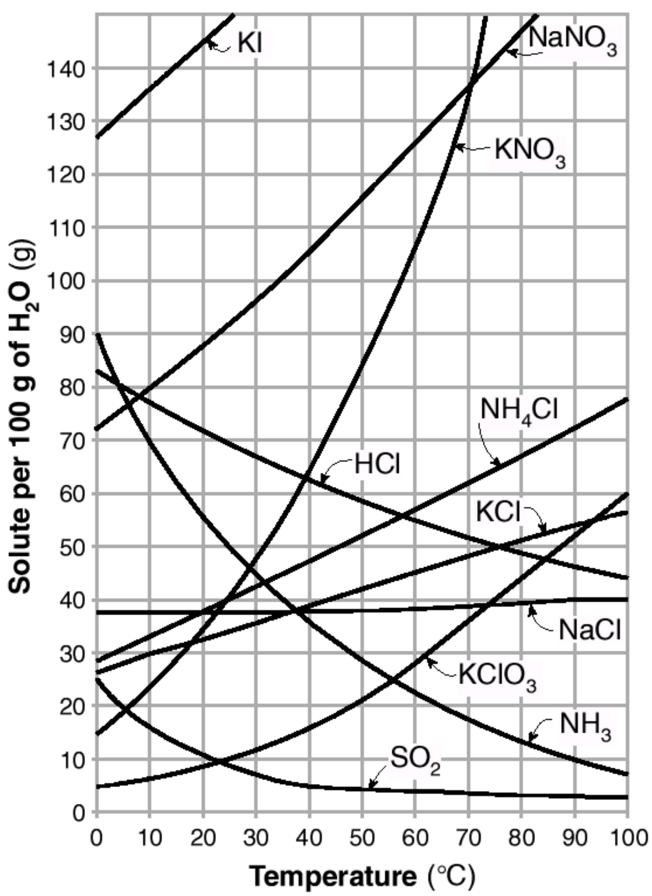


Table G Problems

70 grams of KNO_3 at 50°C in 100 grams of water.

Circle one
Saturated / Unsaturated / Supersaturated

Which compounds on table G are gases?

____

60 g of HCl at 45°C in 100 grams of water

Circle one
Saturated / Unsaturated / Supersaturated

20 g of SO_2 at 20°C in 100 grams of water with no precipitate on the bottom of the container.

Circle one
Saturated / Unsaturated / Supersaturated

20g of NaCl at 90°C in 50 grams of water.

Circle one
Saturated / Unsaturated / Supersaturated

20g of NaCl at 90°C in 200 grams of water.

Circle one
Saturated / Unsaturated / Supersaturated

Table F
Solubility Guidelines for Aqueous Solutions

Ions That Form *Soluble* Compounds	Exceptions
Group 1 ions (Li^+, Na^+, etc.)	
ammonium (NH_4^+)	
nitrate (NO_3^-)	
acetate ($C_2H_3O_2^-$ or CH_3COO^-)	
hydrogen carbonate (HCO_3^-)	
chlorate (ClO_3^-)	
perchlorate (ClO_4^-)	
halides (Cl^-, Br^-, I^-)	when combined with Ag^+, Pb^{2+}, and Hg_2^{2+}
sulfates (SO_4^{2-})	when combined with Ag^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, and Pb^{2+}

Ions That Form *Insoluble* Compounds	Exceptions
carbonate (CO_3^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
chromate (CrO_4^{2-})	when combined with Group 1 ions, Ca^{2+}, Mg^{2+}, or ammonium (NH_4^+)
phosphate (PO_4^{3-})	when combined with Group 1 ions or ammonium (NH_4^+)
sulfide (S^{2-})	when combined with Group 1 ions or ammonium (NH_4^+)
hydroxide (OH^-)	when combined with Group 1 ions, Ca^{2+}, Ba^{2+}, Sr^{2+}, or ammonium (NH_4^+)

One mole of a non / electrolyte in water *raises* the boiling point of water.

One mole of a non / electrolyte in water *lowers* the freezing point of water.

Complete the table below using table F as a guide

Substance	Soluble or Insoluble	# moles produced when put into water	Electrolyte (Yes or No)	Freezing Point (Increases or Decreases)	Boiling Point (Increases or Decreases)
Ag_2SO_4					
NH_4NO_3					
$CaCrO_4$					
$FrClO_4$					
$Ba(OH)_2$					

Molarity

Molarity, **M,** of a solution is the number of **moles of solute** contained in **1 liter of solution**.

In other words:
A 3 **M** solution = 3 moles of solute per liter of solution, or
A 0.5 **M** solution = 0.5 moles of solute per liter of solution

$$\text{molarity} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

1) What is the molarity of a solution that contains 4 grams of NaOH in **500 milliliters** of solution? (formula mass of NaOH = 40 g)

2) What is the molarity of a solution that contains 28 grams of KOH (formula mass = 56) in 2.0 liters of solution?

Relationship Between Density and Molecular Mass

Density = Molecular mass / Volume (use 22.4 when STP is mentioned, yet no volume is given)

The density of a gas is 1.96 g/L at STP. What is its molecular mass?

What is the density of carbon dioxide, CO_2 , at STP?

Unit 6 Review – Kinetics and Equilibrium

Table I
Heats of Reaction at 101.3 kPa and 298 K

Reaction	ΔH (kJ)*
$CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(\ell)$	–890.4
$C_3H_8(g) + 5O_2(g) \longrightarrow 3CO_2(g) + 4H_2O(\ell)$	–2219.2
$2C_8H_{18}(\ell) + 25O_2(g) \longrightarrow 16CO_2(g) + 18H_2O(\ell)$	–10943
$2CH_3OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 4H_2O(\ell)$	–1452
$C_2H_5OH(\ell) + 3O_2(g) \longrightarrow 2CO_2(g) + 3H_2O(\ell)$	–1367
$C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(\ell)$	–2804
$2CO(g) + O_2(g) \longrightarrow 2CO_2(g)$	–566.0
$C(s) + O_2(g) \longrightarrow CO_2(g)$	–393.5
$4Al(s) + 3O_2(g) \longrightarrow 2Al_2O_3(s)$	–3351
$N_2(g) + O_2(g) \longrightarrow 2NO(g)$	+182.6
$N_2(g) + 2O_2(g) \longrightarrow 2NO_2(g)$	+66.4
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(g)$	–483.6
$2H_2(g) + O_2(g) \longrightarrow 2H_2O(\ell)$	–571.6
$N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$	–91.8
$2C(s) + 3H_2(g) \longrightarrow C_2H_6(g)$	–84.0
$2C(s) + 2H_2(g) \longrightarrow C_2H_4(g)$	+52.4
$2C(s) + H_2(g) \longrightarrow C_2H_2(g)$	+227.4
$H_2(g) + I_2(g) \longrightarrow 2HI(g)$	+53.0
$KNO_3(s) \xrightarrow{H_2O} K^+(aq) + NO_3^-(aq)$	+34.89
$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$	–44.51
$NH_4Cl(s) \xrightarrow{H_2O} NH_4^+(aq) + Cl^-(aq)$	+14.78
$NH_4NO_3(s) \xrightarrow{H_2O} NH_4^+(aq) + NO_3^-(aq)$	+25.69
$NaCl(s) \xrightarrow{H_2O} Na^+(aq) + Cl^-(aq)$	+3.88
$LiBr(s) \xrightarrow{H_2O} Li^+(aq) + Br^-(aq)$	–48.83
$H^+(aq) + OH^-(aq) \longrightarrow H_2O(\ell)$	–55.8

*Minus sign indicates an exothermic reaction.

Use table I to correctly put the delta H in this equation.

$N_2 + 2O_2 \rightarrow 2NO_2$

What happens to the reaction above when:

The pressure is increased
- The reaction shifts to the ___________
- The $[O_2]$ ___________ (inc./dec.)
- The $[N_2]$ ___________ (inc./dec.)
- The $[NO_2]$ ___________ (inc./dec.)

The pressure is decreased
- The reaction shifts to the ___________
- The $[O_2]$ ___________ (inc./dec.)
- The $[N_2]$ ___________ (inc./dec.)
- The $[NO_2]$ ___________ (inc./dec.)

The temperature is Increased
- The reaction shifts to the ___________
- The $[NO_2]$ ___________ (inc./dec.)
- The $[O_2]$ ___________ (inc./dec.)
- The $[N_2]$ ___________ (inc./dec.)

The temperature is decreased
- The reaction shifts to the ___________
- The $[NO_2]$ ___________ (inc./dec.)
- The $[O_2]$ ___________ (inc./dec.)
- The $[N_2]$ ___________ (inc./dec.)

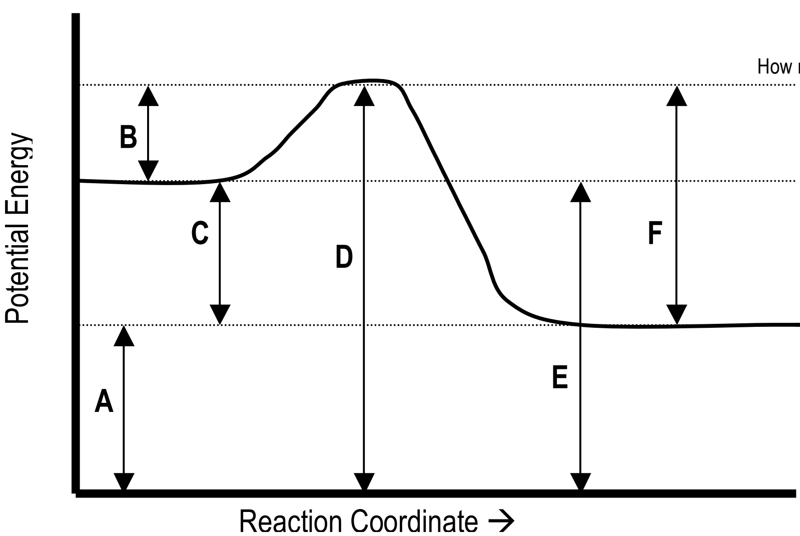
The $[NO_2]$ is Increased
- The reaction shifts to the ___________
- The $[N_2]$ ___________ (inc./dec.)
- The $[O_2]$ ___________ (inc./dec.)

The $[N_2]$ is decreased
- The reaction shifts to the ___________
- The $[NO_2]$ ___________ (inc./dec.)
- The $[O_2]$ ___________ (inc./dec.)

Le Chatliers Principle

What is the **enthalpy** for the ***decomposition*** of **4 moles of NO_2**? _______________

How much energy is absorbed during the synthesis of **1 mole of NO_2**? _______________



$3CO_{(g)} + 3NO_{2\,(g)} \leftrightarrow 3CO_{2\,(g)} + 3NO_{(g)} + 162\ kJ$

Which letter represents the heat of formation? ________

Which letter represents the energy of activation for the reverse reaction? ________

Which letter represents the potential energy of the products? ________

Which letter represents activated complex? ________

Which letter represents the energy of activation of the forward reaction? ________

Which letter represents the potential energy of the reactants? ________

Which **regions** would be affected by the addition of a catalyst to this reaction?

________________ (must have all 3 answers)

Factors that Affect the Rate of a Reaction

The speed of a reaction depends on:

- the number of collisions
- the fraction of those collisions that are **effective**.

Any factor that increases the number of effective collisions will serve to increases the rate of the reaction.

1- Nature of the Reactants
2- Concentrations of the Reactants
3- Temperature
4- Reaction Mechanism
5- Catalysts

Equilibrium

Equilibrium is a state of balance between two opposite reactions, physical or chemical, which are taking place at the same time.

Phase Equilibrium –

Solution Equilibrium

1. *Solids in Liquids*
2. *Gases in Liquids*

What factors enable a reaction to occur spontaneously under a given set of conditions?

1. **THE ENERGY FACTOR**
   - Systems tend to change from higher to lower energy states.
     (⬆Potential Energy to ⬇Potential Energy)
   - Many chemical reactions release energy – Products have less energy than Reactants
   - **Tendency** for **reactions** to **occur spontaneously** when it is an **exothermic** reaction
     (**ΔH is negative**)

2. **THE DISORDER FACTOR**
   - Systems tend to reach a state of higher **disorder** (randomness)
     (ex. Sugar dissolves in water, your bedroom gets messy after a couple of days of neglect.)
   - Disorder is measured by a quantity called **entropy.**
   - Tendency for reactions to occur **spontaneously** when the **entropy increases** (**ΔS is positive**)

EVENTS LEADING TO HIGHER DISORDER

- Temp ⬆ leading to ⬆ in random motion of particles present.
- ***Phase Change:***

Solid (great order, low entropy) ➡**Liquid** (more randomness, higher entropy) ➡ **Gas** (max randomness, highest entropy)

- There are more products than reactants in a chemical reaction.
- When the products of a reaction are simpler than the reactants.

Example of all Events Listed Above

$$2KClO_3 (s) \rightarrow 2KCl (s) + 3O_2 (g) + 875 \text{ kJ}$$

This reaction leads to disorder because:

1.) The Products are simpler
2.) There are more Products
3.) Reaction leads to a Gas
4) Exothermic Reaction

SPONTANEOUS REACTION

A SPONTANEOUS REACTION is one that takes place under a specific set of conditions.

Spontaneous reactions occur in the direction of:

1. **Less energy (lower enthalpy)**: This favors exothermic reactions and
2. **Greater entropy** (randomness, disorder).
   A. Solids have the least entropy, liquids have more, and gases have the most entropy (disorder).
   B. When a solid (examples: salts-NaCl, NH_4Cl; or sugar) dissolves in water, entropy increases.

At low temperature, energy is important, and at high temperature, entropy is important.

Unit 7 Review – Acids and Bases

If you have .000001 M of H_2SO_4, fill in the rest of the chart below

(exponential format) $[H_3O^+]$ =	(exponential format) $[OH^-]$ =
pH =	pOH =
Acidic or Basic or Neutral (circle one)	

If you have pOH of 2, fill in the rest of the chart below

(exponential format) $[H_3O^+]$ =	(exponential format) $[OH^-]$ =
pH =	pOH =
Acidic or Basic or Neutral (circle one)	

If you have pH of 4, fill in the rest of the chart below

(exponential format) $[H_3O^+]$ =	(exponential format) $[OH^-]$ =
pH =	pOH =
Acidic or Basic or Neutral (circle one)	

If you have $[CH_3COOH]$ of .0000001, fill in the rest of the chart below

(exponential format) $[H_3O^+]$ =	(exponential format) $[OH^-]$ =
pOH =	pH =
Acidic or Basic or Neutral (circle one)	

For the three reactions list the conjugate acid-base pairs and answer whether amphoterism is present or not.

$H_2SO_4(aq) + H_2O(l) \leftrightarrow HSO_4^-(aq) + H_3O^+(aq)$
Ex. of Amphoterism? (Y / N)

Conjugate Acid-Base Pair # 1____________ , ___________

Conjugate Acid-Base Pair # 2 ____________ , ___________

$H_2O(l) + H_2O(l) \leftrightarrow H_3O^+(aq) + OH^-(aq)$
Ex. of Amphoterism? (Y / N)

Conjugate Acid-Base Pair # 1____________ , ___________

Conjugate Acid-Base Pair # 2 ____________ , ___________

Given the reaction, $HSO_4^-(aq) + NH_3(g) \leftrightarrow NH_4^+(aq) + SO_4(aq)$, fill in the first blank of each question with either (*Bron.- Low Acid* or *Bron.- Low Base*) and then in the "because it" blank put the operational definition of a Bron. – Low. Acid/Base that accurately describes who is accepting and donating "H^+" (proton), and to whom and from whom the proton is being delivered and accepted from.

$H_2SO_4(aq) + H_2O(l) \leftrightarrow HSO_4^-(aq) + H_3O^+(aq)$

H_2SO_4 is a ___________because it ____.
H_2O is a ____________ because it ____.
HSO_4^- is a ____________ because it ____.
H_3O^+ is a ____________ because it ____.

Which substance can act as an Arrhenius Acid in aqueous solution? 1. NaI 2. HI 3. LiH 4. NH_3

Which solution will turn phenolphthalein pink? 1. HBr(aq) 2. CO_2(aq) 3. LiOH(aq) 4. CH_3OH(aq)

Which compound is a salt? 1. Na_3PO_4 2. H_3PO_4 3. CH_3COOH 4. $Ca(OH)_2$

Red litmus will turn blue when placed in an aqueous solution of 1. KCl 2. KOH 3. CH_3OH 4. CH_3COOH

Which formula releases H^+ and which releases OH^- when put in water ? 1. KOH 2. KCl 3. CH_3OH 4. CH_3COOH

Which relationship is present in a solution that has a pH of 7, pH of 10 and pH of 5?

1. [H+] > [OH-] 2. [H+] = [OH-] 3. [H+] < [OH-] 4. [H+] + [OH-]

Hydrolysis of Salts in Aqueous Solutions

NaCl is the product of the neutralization of HCl by NaOH. In neutralization an acid in equal amount with a base will neutralize producing water and salt. Therefore an aqueous solution of NaCl would be neutral. However, not all salts produce neutral solutions when dissolved in water.

$$HCl + NaOH \rightarrow NaCl + H_2O$$

acid hydroxide base salt water

HI, HBr, HCl, HNO_3 , and H_2SO_4 are strong acids. LiOH, NaOH, KOH, RbOH and CsOH are strong bases.
Combine any of these two and you will get a salt whose aqueous solution is neutral.

However, when a ***weak acid*** is combined with a ***strong base***, a salt, which is *slightly basic* (alkaline), and water is produced.
When a ***strong acid*** is combined with a ***weak base***, a salt, which is *slightly acidic* and water is produced.

This is known as ***HYDROLYSIS***, which is essentially the reverse of a neutralization reaction.

salt of a	***salt of a***	***Hydrolyzes to form a***
strong acid	weak base	Acidic Solution
strong base	Weak acid	Basic Solution
strong acid	strong base	DOES NOT HYDROLIZE

Strong Acids		**Strong Bases**	
HI	HNO_3	NaOH	RbOH
HBr	H_2SO_4	KOH	CsOH
HCl		LiOH	

$$2NaOH + H_2CO_3 \rightarrow Na_2CO_3 + 2H_2O$$

strong base weak acid salt water

*Creates a salt solution that is a slightly **basic solution**, look where **Na_2CO_3** comes from,*

$$Na^+ + OH^- + H^+ + CO_3^{-2} \rightarrow ....$$

$$HI + NH_4OH \rightarrow NH_4I + H_2O$$

strong acid weak base salt water

*Creates a salt solution that is a slightly **acidic solution**, look where **NH_4I** comes from,*

$$H^+ + I^- + NH_4^+ + OH^- \rightarrow ....$$

$$KOH + HCl \rightarrow KCl + H_2O$$

strong acid strong base salt water

*Creates a salt solution that is **neutral**, look where **KCl** comes from,*

$$K^+ + OH^- + H^+ + Cl^{-1} \rightarrow ....$$

Given the compounds H_2SO_4 and KOH:

Write out the resulting reaction **(as a balanced equation)** that occurs when the two are mixed below:

____

What **term** best describes this reaction above? ________________________

Underneath each compound in the final balanced equation, label each compound appropriately (Acid, Base, salt, water)

What could be the pH of the resulting solution (the product) of this reaction? ____________

If the given the compounds were H_2CO_3 and NaOH what could the pH possibly be? ______________________, Why? ___________________________

Table M
Common Acid–Base Indicators

Indicator	Approximate pH Range for Color Change	Color Change
methyl orange	3.2–4.4	red to yellow
bromthymol blue	6.0–7.6	yellow to blue
phenolphthalein	8.2–10	colorless to pink
litmus	5.5–8.2	red to blue
bromcresol green	3.8–5.4	yellow to blue
thymol blue	8.0–9.6	yellow to blue

What color would a solution with a pH of 6.9 possibly be if you were using bromthymol blue?

____

What color would a solution with a pH of 1.7 possibly be if you were using bromcresol green?

____

Unit 8 Review – Redox & Electrochemistry

In which substance is the oxidation number of nitrogen zero?

a) NH_3 b) NO_2 c) N_2 d) N_2O

Oxygen will have a positive oxidation number when combined with

a) fluorine b) chlorine c) iodine d) bromine

In which compound does chlorine have the highest oxidation number?

a) KClO b) $KClO_2$ c) $KClO_3$ d) $KClO_4$

What is the oxidation number of each in:

HSO_4^- H = ___ S = ____ O = ____

What is the oxidation number of each element in: (Be careful and think carefully, make sure to look carefully at the periodic table)

$NaHCO_3$ Na = ___ H = ___ C = ___ O = ____

What is the oxidation number of each in:

$HClO_4$ H = Cl = O =

Fill in the appropriate oxidation numbers for the reaction provided, and then proceed to fill in the chart.

$Co_{(s)} + PbCl_{2\,(aq)} \rightarrow CoCl_{2\,(aq)} + Pb_{(s)}$

Half - Reactions	↓ Include Oxidation numbers ↓	Circle One ↓
Oxidation Half-Reaction =	Which element is oxidized? ________	Ox. or Red. Agent
Reduction Half Reaction =	Which element is reduced? ________	Ox. or Red. Agent
Total Net Reaction =		

Draw an Electrochemical Cell Diagram for the above reaction.

Table J
Activity Series**

Most	Metals	Nonmetals	Most
	Li	F_2	
	Rb	Cl_2	
	K	Br_2	
	Cs	I_2	
	Ba		
	Sr		
	Ca		
	Na		
	Mg		
	Al		
	Ti		
	Mn		
	Zn		
	Cr		
	Fe		
	Co		
	Ni		
	Sn		
	Pb		
	**H_2		
	Cu		
	Ag		
	Au		
Least			Least

**Activity Series based on hydrogen standard

__ Pb^{+2} + __ Au^{+3} → __ Pb^{+4} + __ Au^{0}

Ox: →

Red. →

Balanced Net Reaction:

(Place your final coefficients in the lined spaces provided above.)

Which species is oxidized? _____

Which species is reduced? _____

Which is the oxidizing agent? _____

Which is the reducing agent? _____

ANnie
The homicidal
OX

RED
the dead
CAT

Given the equations A, B, C, and D: (A) $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$ (B) $Cl_2 + H_2O \rightarrow HClO + HCl$ (C) $CuO + CO \rightarrow CO_2 + Cu$ (D) $NaOH + HCl \rightarrow NaCl + H_2O$

Which two equations represent redox reactions?

1. A and B
2. B and C
3. C and A
4. D and B

Which half-reaction correctly represents oxidation?

1. $Mg + 2e^- \rightarrow Mg^{+2}$
2. $Mg^{+2} + 2e^- \rightarrow Mg$
3. $Mg^{+2} \rightarrow Mg + 2e^-$
4. $Mg \rightarrow Mg^{+2} + 2e^-$

Which half-reaction correctly represents reduction?

1. $Fe^{+2} + 2e^- \rightarrow Fe$
2. $Fe^{+2} + e^- \rightarrow Fe^{+3}$
3. $Fe + 2e^- \rightarrow Fe^{+2}$
4. $Fe + e^- \rightarrow Fe^{+3}$

The reaction $2H_2O(l) \rightarrow 2H_2(g) + O_2(g)$ is forced to occur by use of an externally applied electric current. This procedure is called

1. neutralization
2. esterification
3. electrolysis
4. hydrolysis

Draw an electrolytic cell for the plating of copper on a fork.

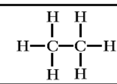
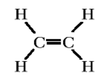
Describe the *major* differences between an electrolytic cell and an electrochemical cell.

Unit 9 Review – Organic Chemistry

Table P
Organic Prefixes

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	H—C≡C—H

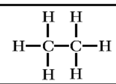
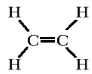
n = number of carbon atoms

Table R
Organic Functional Groups

Class of Compound	Functional Group	General Formula	Example
halide (halocarbon)	—F (fluoro-) —Cl (chloro-) —Br (bromo-) —I (iodo-)	*R*—*X* (*X* represents any halogen)	$CH_3CHClCH_3$ 2-chloropropane
alcohol	—OH	*R*—OH	$CH_3CH_2CH_2OH$ 1-propanol
ether	—O—	*R*—O—*R′*	$CH_3OCH_2CH_3$ methyl ethyl ether
aldehyde	—C(=O)—H	*R*—C(=O)—H	$CH_3CH_2C(=O)—H$ propanal
ketone	—C(=O)—	*R*—C(=O)—*R′*	$CH_3C(=O)CH_2CH_2CH_3$ 2-pentanone
organic acid	—C(=O)—OH	*R*—C(=O)—OH	$CH_3CH_2C(=O)—OH$ propanoic acid
ester	—C(=O)—O—	*R*—C(=O)—O—*R′*	$CH_3CH_2C(=O)OCH_3$ methyl propanoate
amine	—N(—)—	*R*—N(—*R′*)—*R″*	$CH_3CH_2CH_2NH_2$ 1-propanamine
amide	—C(=O)—NH(—)	*R*—C(=O)—NH(—*R′*)	$CH_3CH_2C(=O)—NH_2$ propanamide

R represents a bonded atom or group of atoms.

Table Q
Homologous Series of Hydrocarbons

Name	General Formula	Examples	
		Name	Structural Formula
alkanes	C_nH_{2n+2}	ethane	
alkenes	C_nH_{2n}	ethene	
alkynes	C_nH_{2n-2}	ethyne	H—C≡C—H

n = number of carbon atoms

Write the chemical formula and Draw the Structural Formula for the Homologous Alkane Series:

<u>Name</u> **<u>Structural Formula</u>**

Methane
CH_4

Ethane

____

Propane

____

Butane

____

Pentane

____

Octane

____

---

30. Write the structural formula for 3-methyl pentane.

31. Write the structural formula for 2, 2-dimethyl hexane.

32. Write the structural formula for 2-methyl, 3-ethyl hexane.

Table P
Organic Prefixes

Prefix	Number of Carbon Atoms
meth-	1
eth-	2
prop-	3
but-	4
pent-	5
hex-	6
hept-	7
oct-	8
non-	9
dec-	10

<u>Name</u> **<u>Structural Formula</u>**

Ethene

____

Propene

____

2-Butene

____

2-Pentene

____

2-Octene

____

<u>Name</u> **<u>Structural Formula</u>**

Ethyne

____

Propyne

____

2-Butyne

____

2-Pentyne

____

2-Octyne

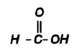
____

Table R

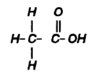
Class of Compound	Functional Group	General Formula
Organic Acid	$-\overset{O}{\overset{\|}{C}}-OH$	$R-\overset{O}{\overset{\|}{C}}-OH$

ORGANIC ACIDS have the functional group $-\overset{O}{\overset{\|}{C}}-OH$, as shown in Table R, second column. Organic acids can be shown by $R-\overset{O}{\overset{\|}{C}}-OH$, given in the third column of Table R. "R" can be CH_3-methyl, C_2H_5-ethyl, etc. They are named by dropping the final "e" from the corresponding alkane and **adding "oic acid."**

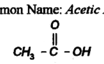
The first two members of the organic acid series are formic acid and acetic acid:



Methanoic Acid
"meth" means 1 carbon atom
Common Name: *Formic Acid*



Ethanoic Acid
"eth" means 2 carbon atoms
Common Name: *Acetic Acid*



Condensed Formula

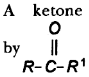
Organic acids, like other acids (example: HCl) are **electrolytes.** When they are dissolved in water, they **conduct** an **electric current.**

Table R

Class of Compound	Functional Group	General Formula
Ketone	$-\overset{O}{\overset{\|}{C}}-$	$R-\overset{O}{\overset{\|}{C}}-R^1$

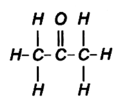
In a **KETONE**, the C=O bond is in the middle, and carbon atoms are on both sides of C=O, as shown in Table R, to the left, or on page Reference Tables 22.

A ketone can be shown by



.

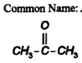
R and R^1 are hydrocarbon groups which contain C. Ketones are named by dropping the final "e" from the corresponding alkane and adding one. Ket**one**, add **one**. ("o" has the sound of "o" in the word "own.")



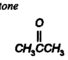
Propanone
"pro" means 3 C atoms
"-one" at the end of the word means a ketone.
Common Name: *Acetone*

By looking at the structural or condensed formula, you know it is a **ketone**, because it has the functional group $-\overset{O}{\overset{\|}{C}}-$ in the middle of the compound (see Table R).

The condensed formula can be written with or without the single line between the carbon atoms. (See formulas to the right.)



Condensed Formula



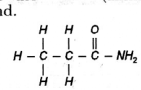
Condensed Formula

Table R

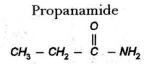
Class of Compound	Functional Group
Amide	$-\overset{O}{\overset{\|}{C}}-NH$

An **AMIDE** has the functional group $-\overset{O}{\overset{\|}{C}}-NH$ (see Table R) at the end of a carbon chain. The carbon is attached to the oxygen by a double bond and to the $-NH$ (amine group) by a single bond.

Amides are named by dropping the final "e" from the name of the hydrocarbon and adding -amide.



Propanamide



Condensed Formula

SUMMARY: When you see $-\overset{O}{\overset{\|}{C}}-NH$, you know it is an amide.

Table R

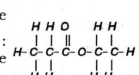
Class of Compound	Functional Group
Ester	$-\overset{O}{\overset{\|}{C}}-O-$

An **ESTER** has $-\overset{O}{\overset{\|}{C}}-O-$ between two carbon chains. The carbon is attached to one oxygen by a double bond and to the other oxygen by a single bond.

An ester is formed by the reaction of an acid and an alcohol.

To name an ester:

1. Look at the carbon chain after the $-\overset{O}{\overset{\|}{C}}-O-$; write its prefix (example: meth-, eth-, etc.) and add -yl to the end of the prefix.
   In this formula, prefix eth- and -yl equal ethyl.



Ethyl Propanoate

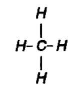
2. Then give the name of the carbon chain that includes the C=O (propane); leave off the last letter and add -oate; in this case, propanoate. This example is ethyl propanoate.

Hint: Compare example of ester given in Table R.

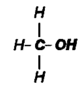
Esters have fruity odors (examples: banana, pineapple, apple).

SUMMARY: When you see $-\overset{O}{\overset{\|}{C}}-O-$ **between two carbon chains, you know it is an ester.**

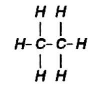
Primary Alcohols



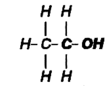
CH_4
(methane)



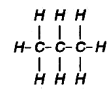
CH_3OH **(methanol.** or methyl alcohol)
Take away one H from CH_4 and add OH.



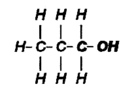
C_2H_6
(ethane)



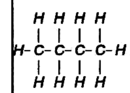
C_2H_5OH **(ethanol,** or ethyl alcohol)
Take away one H from C_2H_6 and add OH.



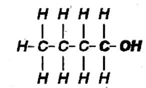
C_3H_8
(propane)



C_3H_7OH **(propanol,** or propyl alcohol)
Replace one H with OH



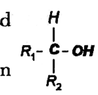
C_4H_{10} (butane)



C_4H_9OH **(butanol,** or butyl alcohol)
Replace one H with OH

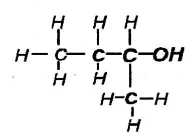
As you can see, methanol, ethanol, propanol and butanol are examples of primary alcohols because the C that is attached to the OH group is attached only to ONE CARBON, OR TO NO CARBON ATOMS.

SECONDARY ALCOHOLS: The C attached to OH is attached to **two other C atoms.**

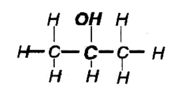


R_1, R_2 = hydrocarbon radical, and has C in it. R_1, R_2 can be CH_3, C_2H_5, etc.

Example of secondary alcohol:

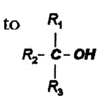


or



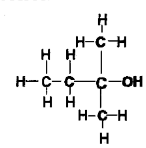
The C attached to the OH is attached to TWO OTHER C ATOMS.

TERTIARY ALCOHOLS: The C attached to OH is attached to **three** other carbon atoms.



R_1, R_2, R_3 = hydrocarbon radical, and has C in it.

Example of tertiary alcohol:

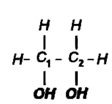


The C attached to the OH is attached to THREE OTHER C ATOMS.

DIHYDROXY ALCOHOLS: Compounds containing **two OH groups** are called **dihydroxy** (dihydric) **alcohols** or **glycols.** Example: Ethylene glycol (see structure on second page of Section B).

TRIHYDROXY ALCOHOLS: Compounds with **three OH groups** are known as **trihydroxy** (trihydric) **alcohols.** Example: Glycerol (see structure on second page of Section B).

Dihydroxy and Trihidroxy Alcohols



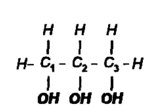
1,2-ethanediol
Common Name:
Ethylene glycol

1,2-ethanediol: ethane = 2 carbon atoms with single bonds; *diol* = 2 OH.

It is called 1,2-ethanediol because OH is attached to the first and second carbon atoms, C_1 and C_2.

Commonly called **ethylene glycol**, *antifreeze.*

Ethylene glycol has 2 OH groups.



1,2,3-propanetriol
Common Name:

3 carbons with single bonds = propane.

3 OH = triol

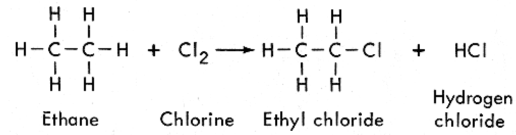
OH is attached to the first, second and third carbon atoms: C_1, C_2 and C_3, therefore: 1,2,3-propanetriol.

Glycerol has 3 OH groups.

Organic Reactions

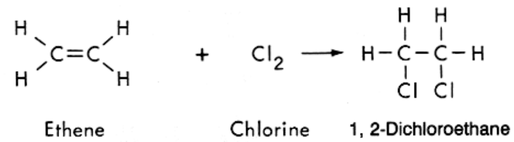
SUBSTITUTION REACTION

- the replacement of one kind of atom or group by another kind of atom or group.
- An example of this occurs in saturated hydrocarbons where a hydrogen is replaced.
- If the hydrogen is replaced by a halogen (**F,Cl, Br, I, At**) ***halogenation*** is said to have occurred. The products of such a reaction are termed ***halogen derivatives.***



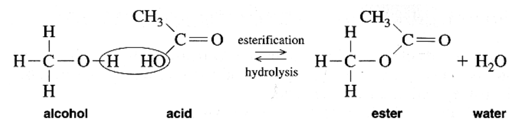
ADDITION REACTION

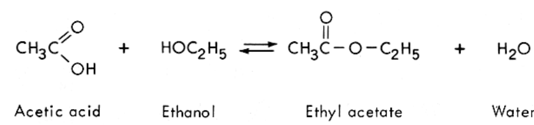
- The adding of one or more atoms or groups at a double or triple bond.
- The double or triple bond is changed to a single (saturated) bond or double bond.
- If hydrogen is added, the process is referred to as ***hydrogenation***.
- Addition is characteristic of unsaturated compounds (halogens like to be added to these compounds)
- Addition takes place more rapidly than substitution reactions.



ESTERIFICATION

- Organic acids (COOH) react with alcohol's to produce an **ester** plus **water**.
- The process is reversible (like equilibrium) and slow and is called **esterification**.
- Esterification = acid + alcohol ←→ ester + water
- Fats are esters that are derived from glycerol, a trihydroxy alcohol.
- Esters have a pleasant odor.
- Esterification is also referred to as a ***hydrolysis*** *(in the reverse)* and is considered to be a ***dehydration reaction*** (water product) or ***condensation*** (water product).





SAPONIFICATION

- the hydrolysis of a fat with a base such as NaOH, which produces glycerol and salts of fatty acids known as **SOAP**.
  Fat + NaOH → glycerol + SOAP
- saponification can also be looked at as the hydrolysis of an ester (since fat is an ester technically).

FERMENTATION

- chemical process where molecules are broken down.
- For example, zymase, an enzyme (which act as catalysts) from yeast, breaks down glucose to ethanol, and carbon dioxide.
- Ethanol, the alcoholic beverage alcohol, and carbon dioxide, the carbonation of the beverage. ----- ex. Beer.

$$C_6H_{12}O_6 \xrightarrow{\text{yeast enzymes}} 2C_2H_5OH + 2CO_2$$

glucose **ethanol** **carbon dioxide**

$$C_6H_{12}O_6 \xrightarrow{\text{zymase}} 2\,C_2H_5OH + 2\,CO_2$$

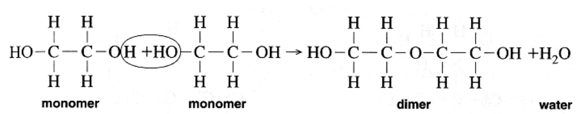
Glucose Ethanol Carbon dioxide

OXIDATION

- When saturated hydrocarbons (like methane) react with oxygen at a high temperature and produce carbon dioxide and water.
  $CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$
- Oxidation makes alkanes suitable as fuels. With various amounts of oxygen, carbon monoxide and carbon soot is produced.
  $2CH_4 + 3O_2 \rightarrow CO_2 + 4H_2O$ **and** $CH_4 + O_2 \rightarrow CO_2 + 2H_2O$

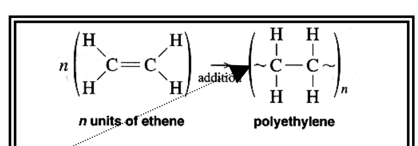
POLYMERIZATION

- A **polymer** is a large molecule composed of many repeating units called ***monomers***.
- In polymerization, a number of monomers join to form a polymer.
- **Natural polymers**: proteins, cellulose, starch
- **Synthetic polymers:** plastic polyethylene, nylon and polyester.



Condensation Polymerization

- Monomers are joined by a ***dehydration reaction*** (water is released)
- This will continue to grow as additional monomers attach to the dimer.
- Ex. Silicones, nylons, polyester



Addition Polymerization

- Monomers that are unsaturated undergo polymerization by addition reactions with each other.
- The double or triple bonds are reduced to single or double bonds just like we learned earlier in addition reactions.

$$nC_2H_4 \rightarrow (C_2H_4)n$$

ethene polyethylene

Note here that the "~" denotes the repeated ethene units.