Name:_____ **Score:**_____**/100**

Part I. Multiple choice. Write the letter of the correct answer for each problem. 3 points each

1. When HCl is added to pure water, HCl molecules lose protons, while water molecules gain protons. In this reaction, water is a(n)?

   A) base C) salt
   B) acid D) solute Answer ___**A**____

2. Uranium-238 decays by emission of an alpha particle. The other product of this decay is

   A) $^{234}_{92}U$ B) $^{234}_{91}Pa$ C) $^{234}_{88}Ra$ D) $^{234}_{90}Th$ Answer ___**D**____

3. One difference between a chemical reaction and a nuclear reaction is that in a nuclear reaction

   A) only small amounts of energy are absorbed or emitted.
   B) only the valence electrons are involved. Answer ___**D**____
   C) atoms retain their identity.
   D) atoms often change from one element to another.

4. The same number of moles of acetic acid and hydrogen chloride are placed in beakers containing water. After this addition, the beaker with the HCl has more hydronium ions than the beaker with added acetic acid. HCl is classified as

   A) equal in acid strength to acetic acid
   B) a weaker acid than acetic acid. Answer ___**N/A**__
   C) is very concentrated.
   D) A base.

5. An unknown substance is added to a solution and the pH increases. The substance is best described as a(n?

   A) base C) salt
   B) acid D) solvent Answer ___**A**____

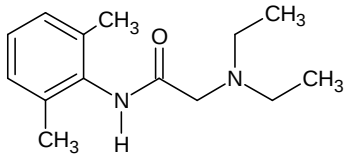
6. The general formula for a carboxylic acid is

   A) RCOOR'. C) RCOR'.
   B) RCOOH. D) ROR'. Answer ___**B**____

7. The molecule most commonly produced as a byproduct of condensation polymerization is

   A) HCl. C) NH_3.
   B) H_2O. D) H_2S. Answer ___**B**____

8. Lidocaine, shown below, is both a local anesthetic and an antiarrhythmic drug. In emergency medical situations, patients with irregular heartbeats frequently receive lidocaine injections or drips. What is the molecular formula of lidocaine?



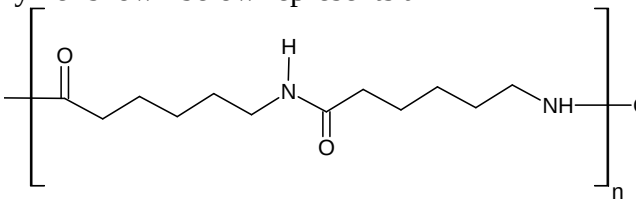
   A) $C_{14}H_{20}N_2O$ C) $C_{14}H_{13}N_2O$
   B) $C_{14}H_{17}N_2O$ D) $C_{14}H_{22}N_2O$ Answer ___**D**____

9. Constitutional isomers are compounds that have

A) the same chemical formulas and molecular structures but different physical properties.
B) the same chemical formulas but different molecular structures and physical properties.
C) different chemical formulas and molecular structures but the same physical properties.
D) the same chemical formulas, molecular structures and physical properties.

Answer ___**B**____

10. The segment of a polymer shown below represents a



A) polyester.
B) polyamide.
C) polyethylene.
D) polystyrene.

Answer ___**B**____

11. Which of the following is the correct balanced equation for the neutralization of barium hydroxide with sulfuric acid?

A) $Ba(OH)_2 + 2\ H_2SO_4 \rightarrow Ba(SO_4)_2 + 2\ H_2O$
B) $BaOH + H_2SO_4 \rightarrow BaSO_4 + 2\ H_2O$
C) $BaOH_2 + H_2SO_4 \rightarrow BaSO_4 + H_2O$
D) $Ba(OH)_2 + H_2SO_4 \rightarrow BaSO_4 + 2\ H_2O$

Answer ___**D**____

12. The pH of a sample of water from a river is 6.0. A sample of wastewater from a food processing plant has a pH of 4.0. The concentration of hydronium ion in the wastewater is

A) two times *larger* than the river hydronium ion concentration.
B) one hundred times *larger* than the river hydronium ion concentration.
C) two times *smaller* than the river hydronium ion concentration.
D) one hundred times *smaller* than the river hydronium ion concentration.

Answer ___**B**____

13. Which statement relating to monomers and polymers is correct?

A) The monomer is usually a solid, while the polymer is usually a liquid or gas.
B) They have the same chemical and physical properties.
C) They have different chemical and physical properties.
D) They have the same chemical formula.

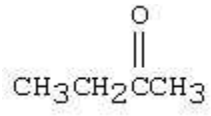
Answer ___**C**____

14. A compound containing only carbon and hydrogen and which has no double bonds between atoms is classified as an

A) aromatic
B) alkane
C) alkene
D) alkyne

Answer ___**B**____

15. The compound below is a(n)



A) ketone.
B) alcohol.
C) carboxylic acid.
D) aldehyde.

Answer ___**A**____

16. Which of the following statements about addition and condensation polymers is true?

A) Both addition polymers and condensation polymers contain all of the atoms of the monomers.
B) Condensation polymers contain all of the atoms of the original monomers, but addition polymers do not.
C) Addition polymers contain all of the atoms of the original monomers, but condensation polymers do not.
D) Both addition polymers and condensation polymers lose some atoms from the original monomers when the polymer is formed.

Answer ___**C**____

17. Which of the following will result from adding a plasticizer to a polymer?

A) They will be more rigid.
B) They will be more transparent.
C) They will be more colorful.
D) They will be less brittle.

Answer ___**D**____

18. Thorium-234 undergoes beta decay as shown below. What is Q?

$$^{234}_{90}\text{Th} \rightarrow {}^{0}_{-1}\beta + \text{Q}$$

A) $^{234}_{91}$Pa B) $^{233}_{91}$Th C) $^{233}_{90}$Th D) $^{234}_{89}$Ac

Answer ___**A**____

19. After three half-lives, what fraction of the original radioactive isotope remains in a sample?

A) 1/4 B) 1/8 C) 1/16 D) none

Answer ___**B**____

20. The mass of a helium nucleus is slightly less than the sum of its parts (2 protons and 2 neutrons) because

A) the mass of protons and neutrons are not precisely known.
B) some of the mass is given to electrons.
C) the mass of a proton is larger than the mass of a neutron.
D) some of the mass is converted to binding energy.

Answer ___**D**____

Part II. Complete each of the following. Point values are noted by each question.

21. Complete the following table: (4 points)

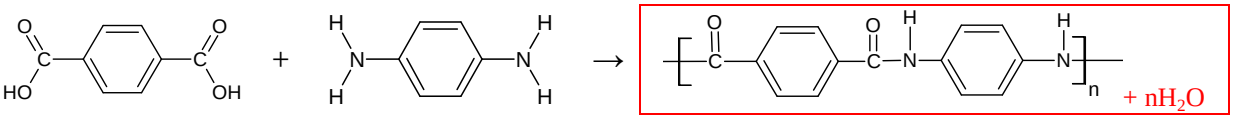
H^+ molarity	pH	Acidic, Basic or Neutral?
3.89×10^{-6} M	5.41	acidic
1.6×10^{-9} M	8.80	basic

22. Match the term with its definition. (8 points)

__B__stereoisomers
__A__radical
__K__critical mass
__F__alpha particle
__J__functional groups
__H__fusion
__E__binding energy
__C__basic

A. a reactive species with on unpaired electron
B. compounds that have the same chemical formula and bonding but different arrangement in space
C. A solution with pH > 7
D. A solution with pH < 7
E. The force that holds the nucleons together in an atom's nucleus
F. A helium nucleus emitted in nuclear reaction
G. An electron emitted in a nuclear reaction
H. The combination of two smaller nuclei to produce one larger nucleus
I. The splitting of an atomic nucleus into two smaller nuclei
J. Parts of organic molecules that give compounds characteristic chemical and physical properties
K. The minimum amount of an isotope necessary to sustain a chain reaction.

23. Kevlar, a poly**amide** used to make bulletproof vests, is made from terephthalic acid and para-phenylenediamine. Write the polymerization reaction for the formation of Kevlar, indicating the repeating structure for the polymer. (4 points)

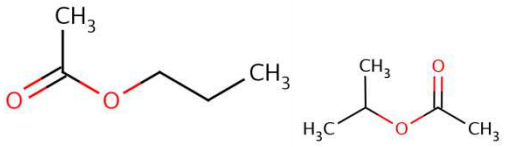


terephthalic acid

para-phenylene diamine

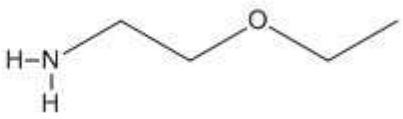
24. Draw organic compounds that fit the following criteria (there may be more than one structure that fits the criteria, you only need to draw one example for each):

a. A compound that contains an ester and has the formula $C_5H_{10}O_2$. (2 points)



Here are examples of possible structures:

b. A compound that contains and amine and an ether and has the formula $C_4H_{11}NO$. (2 points)



Here's an example of one possible structure:

Part III. ***Complete 3 of the following 4 problems.*** Clearly mark the problem you do not want graded. Each problem is worth eight (8) points. You must show you work on calculations to receive partial credit. Report numerical results to the correct number of significant figures and with the appropriate units.

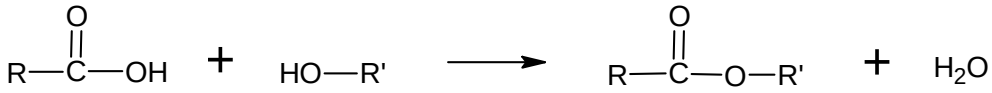
25. Rank these solutions in order of increasing concentration of H^+ (or H_3O^+) ions. Explain your reasoning.

$0.10\ M\ NH_3 \quad 0.10\ M\ CH_3COOH \quad 0.10\ M\ HNO_3$

You should talk about the fact that HNO_3 is a strong acid, CH_3COOH is a weak acid, and NH_3 is a base. We would expect the strong acid to dissociate completely to produce 0.10 M H^+ ions, while the weak acid should dissociate less completely to still produce H^+, but at a lesser concentration. The NH_3 will not produce H^+, so its H^+ concentration in solution should be least.

$HNO_3 > CH_3COOH > NH_3$

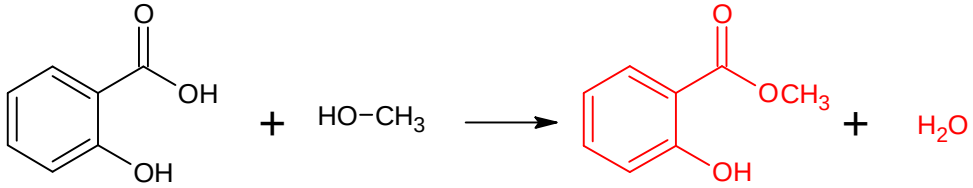
26. Alcohols and carboxylic acids react to form compounds by the process shown below.



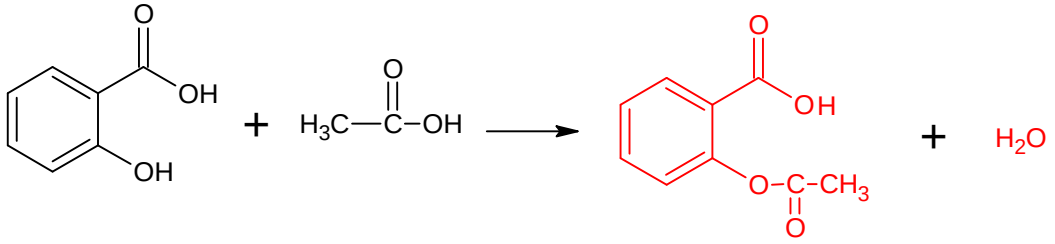
a. What type of functional group is formed when alcohols and carboxylic acids react? (2 points)

An ester group forms

b. Complete the reaction of salicylic acid with methanol to form methyl salicylate (oil of wintergreen). (3 points)



c. Complete the reaction of salicylic acid with acetic acid to form acetylsalicylic acid (aspirin). (3 points)



27. Einstein's mass-energy equation, $E=mc^2$ uses the speed of light (3.00×10^8 m/s) to relate mass in kilograms and energy in joules.
    a. Calculate the energy released, in joules, when 10.0 grams of matter is converted to energy.

$$10.0\text{ g} \times \frac{1\text{ kg}}{1000\text{ g}} = 0.0100\text{ kg}$$

$$E = mc^2 = 0.0100\text{ kg} \times (3.00 \times 10^8\text{ m/s})^2 = 9.00 \times 10^{14}\text{J}$$

    b. When methane burns, it releases approximately 890 kJ per mole of methane. If the molar mass of methane is 16.0 g/mol, how many grams of methane must burn to release the same amount of energy as you calculated in part a?

$$9.00\text{x}10^{14}\text{J} \times \frac{1\text{ mol}}{890\text{ kJ}} \times \frac{1\text{ kJ}}{1000\text{ J}} \times \frac{16\text{ g}}{1\text{ mol}} = 1.61\text{x}10^{10}\text{ g methane}$$

28. Compounds that can serve as monomers for polymerization reactions must have one key property. What property is this? Show how this property manifests itself in both addition and condensation polymerization.

Monomers must be able to react in two locations in order for the polymer to continue to grow. For addition polymerization, the alkene produces a di-radical that can react in two locations and continue to grow. For condensation polymerization, the monomers must have two functional groups that can react independently. (Example structures would be useful here.)

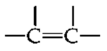
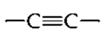
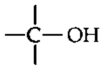
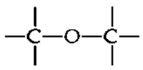
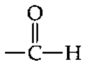
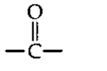
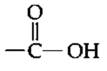
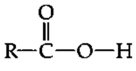
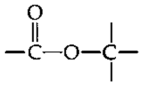
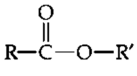
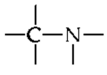
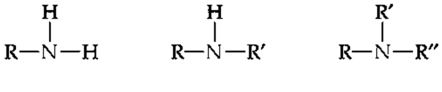
$pH = -\log[H^+]$	$[H^+] = 10^{-pH}$
$[H^+][OH^-] = 1.0 \times 10^{-14}$	$N_A = 6.02 \times 10^{23}\ mol^{-1}$

Periodic Table of the Elements

1 IA 1A	2 IIA 2A	3 IIIB 3B	4 IVB 4B	5 VB 5B	6 VIB 6B	7 VIIB 7B	8	9 VIII 8	10	11 IB 1B	12 IIB 2B	13 IIIA 3A	14 IVA 4A	15 VA 5A	16 VIA 6A	17 VIIA 7A	18 VIIIA 8A
1 H Hydrogen 1.008																	2 He Helium 4.003
3 Li Lithium 6.941	4 Be Beryllium 9.012											5 B Boron 10.811	6 C Carbon 12.011	7 N Nitrogen 14.007	8 O Oxygen 15.999	9 F Fluorine 18.998	10 Ne Neon 20.180
11 Na Sodium 22.990	12 Mg Magnesium 24.305											13 Al Aluminum 26.982	14 Si Silicon 28.086	15 P Phosphorus 30.974	16 S Sulfur 32.066	17 Cl Chlorine 35.453	18 Ar Argon 39.948
19 K Potassium 39.098	20 Ca Calcium 40.078	21 Sc Scandium 44.956	22 Ti Titanium 47.867	23 V Vanadium 50.942	24 Cr Chromium 51.996	25 Mn Manganese 54.938	26 Fe Iron 55.845	27 Co Cobalt 58.933	28 Ni Nickel 58.693	29 Cu Copper 63.546	30 Zn Zinc 65.38	31 Ga Gallium 69.723	32 Ge Germanium 72.631	33 As Arsenic 74.922	34 Se Selenium 78.971	35 Br Bromine 79.904	36 Kr Krypton 83.798
37 Rb Rubidium 85.468	38 Sr Strontium 87.62	39 Y Yttrium 88.906	40 Zr Zirconium 91.224	41 Nb Niobium 92.906	42 Mo Molybdenum 95.95	43 Tc Technetium 98.907	44 Ru Ruthenium 101.07	45 Rh Rhodium 102.906	46 Pd Palladium 106.42	47 Ag Silver 107.868	48 Cd Cadmium 112.414	49 In Indium 114.818	50 Sn Tin 118.711	51 Sb Antimony 121.760	52 Te Tellurium 127.6	53 I Iodine 126.904	54 Xe Xenon 131.294
55 Cs Cesium 132.905	56 Ba Barium 137.328	57-71	72 Hf Hafnium 178.49	73 Ta Tantalum 180.948	74 W Tungsten 183.84	75 Re Rhenium 186.207	76 Os Osmium 190.23	77 Ir Iridium 192.217	78 Pt Platinum 195.085	79 Au Gold 196.967	80 Hg Mercury 200.592	81 Tl Thallium 204.383	82 Pb Lead 207.2	83 Bi Bismuth 208.980	84 Po Polonium [208.982]	85 At Astatine 209.987	86 Rn Radon 222.018
87 Fr Francium 223.020	88 Ra Radium 226.025	89-103	104 Rf Rutherfordium [261]	105 Db Dubnium [262]	106 Sg Seaborgium [266]	107 Bh Bohrium [264]	108 Hs Hassium [269]	109 Mt Meitnerium [278]	110 Ds Darmstadtium [281]	111 Rg Roentgenium [280]	112 Cn Copernicium [285]	113 Nh Nihonium [286]	114 Fl Flerovium [289]	115 Mc Moscovium [289]	116 Lv Livermorium [293]	117 Ts Tennessine [294]	118 Og Oganesson [294]

Lanthanide Series	57 La Lanthanum 138.905	58 Ce Cerium 140.116	59 Pr Praseodymium 140.908	60 Nd Neodymium 144.243	61 Pm Promethium 144.913	62 Sm Samarium 150.36	63 Eu Europium 151.964	64 Gd Gadolinium 157.25	65 Tb Terbium 158.925	66 Dy Dysprosium 162.500	67 Ho Holmium 164.930	68 Er Erbium 167.259	69 Tm Thulium 168.934	70 Yb Ytterbium 173.055	71 Lu Lutetium 174.967
Actinide Series	89 Ac Actinium 227.028	90 Th Thorium 232.038	91 Pa Protactinium 231.036	92 U Uranium 238.029	93 Np Neptunium 237.048	94 Pu Plutonium 244.064	95 Am Americium 243.061	96 Cm Curium 247.070	97 Bk Berkelium 247.070	98 Cf Californium 251.080	99 Es Einsteinium [254]	100 Fm Fermium 257.095	101 Md Mendelevium 258.1	102 No Nobelium 259.101	103 Lr Lawrencium [262]

Table 9.4 Selected Organic Functional Groups

Name of Class	Functional Group[a]	General Formula of Class
Alkane	None	R—H
Alkene		$R_2C{=}CR_2$
Alkyne		$RC{\equiv}CR$
Alcohol		R—OH
Ether		R—O—R′
Aldehyde		
Ketone		
Carboxylic acid		
Ester		
Amine		
Amide