JBA 2019 – Chemistry Exam 3

Name:_____ Score:_____/100 = _____/80

Multiple choice questions are worth two points each.

1. If acids are compounds that donate protons (H^+), how is it that SO_x and NO_x cause acid rain?

   a. They react with hydrogen gas in the atmosphere to produce acids.
   b. There is not sufficient evidence to indicate that these compounds actually do cause acid rain.
   c. They react with water to form acids.
   d. They react with ammonia to form acids.

   Answer ___c____

2. The compound CH_3NH_2 reacts with water to form $CH_3NH_3^+$ and OH^-. In this reaction, CH_3NH_2 is acting as a(n)

   a. salt
   b. base
   c. acid
   d. solvent

   Answer ___b____

3. H_3O^+ is called the

   a. hydroxide ion
   b. hydrogen ion
   c. hydrate ion
   d. hydronium ion

   Answer ___d____

4. If the concentration of a dilute solution of nitric acid (HNO_3) is 0.00010 M, what is the pH of that solution?

   a. 14.0
   b. 7.0
   c. 4.0
   d. 5.0

   Answer ___c____

5. 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____

6. 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____

7. 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.
c. atoms retain their identity.
d. atoms often change from one element to another.

Answer ___d____

8. All of the following examples are classified as potential energy except

a. energy in chemical bonds.
b. energy of a moving object.
c. energy in nuclear particles.
d. energy stored by position.

Answer ___b____

9. In our demo with the inverted flask and green water on Thursday, the primary reason the liquid moved into the flask was

a. The pressure inside the flask increased compared to the pressure outside the flask.
b. The pressure inside the flask decreased compared to the pressure outside the flask
c. The combustion of the matches produced carbon dioxide.
d. The temperature inside the flask increased during the demo.

Answer ___b____

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

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

a. $^{234}_{91}Pa$ b. $^{233}_{91}Th$ c. $^{233}_{90}Th$ d. $^{234}_{89}Ac$

Answer ___a____

11. 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____

12. 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____

10. Match the term with its definition. (10 points)

__E__ pH	A. a concentration term expressed in moles per liter
__H__ alpha particle	B. a compound that can behave both as an acid and as a base
__A__ molarity	C. A solution with pH > 7
__B__ amphiprotic	D. The force that holds the nucleons together in an atom's nucleus
__J__ critical mass	E. -log[H^+]
__D__ binding energy	F. the substance in which a solute is dissolved
__I__ state function	G. energy transferred as heat
__G__ enthalpy	H. A helium nucleus emitted in nuclear reaction
__C or K__ basic	I. a thermodynamic concept that does not depend on pathway (or mechanism).
__L__ thermodynamics	J. The minimum amount of an isotope necessary to sustain a chain reaction.
	K. A solution with pH > 7
	L. The study of energy and its transfer

11. Write reactions for the following: (2 points each)

a. The dissociation of nitric acid (HNO_3, a strong acid)

$$HNO_3 \rightarrow H^+ + NO_3^-$$

b. The dissociation of calcium hydroxide ($Ca(OH)_2$, a strong base)

$$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$$

c. The reaction of nitric acid (HNO_3) with calcium hydroxide ($Ca(OH)_2$).

$$HNO_3 + Ca(OH)_2 \rightarrow Ca(NO_3)_2 + 2H_2O$$

Please write legibly! If I can't read it, I can't grade it!

12. Complete the following table: (10 points)

Compound	Molarity	pH	pOH	Acidic, Basic or Neutral?
H_2SO_4	0.012 M	$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$ So, $[H^+] = 2(0.012) =$ 0.024 M, **pH =1.62**	12.38	Acidic
KOH	0.0035 M	11.54	$KOH \rightarrow K^+ + OH^-$ $[OH^-] = 0.0035$ M **pOH = 2.46**	Basic

13. Write the nuclear equation for the decay of Po-210 if it undergoes 2 consecutive alpha decay followed by a beta decay followed by another alpha decay? (8 points)

$$^{210}_{84}Po \rightarrow 3\,^{4}_{2}He + {}^{0}_{-1}e + {}^{198}_{79}Au$$

14. In a beaker, you mix 35.0 mL of 0.100 M H_2SO_4 and 30.0 mL of 0.200 M NaOH (8 points)

a. Write the balanced reaction that you would expect to occur. (2 points)

$$H_2SO_4 + 2NaOH \rightarrow Na_2SO_4 + 2H_2O$$

b. When the reaction is complete, will the resulting solution be acidic, basic, or neutral? Explain your decision. (*hint: figure out which reactant is in excess*) (8 points)

We have

$$0.035\text{ L } H_2SO_4 \times \frac{0.100\text{ mol } H_2SO_4}{1\text{ L}} = 0.0035\text{ mol } H_2SO_4$$

and

$$0.030\text{ L NaOH} \times \frac{0.200\text{ mol NaOH}}{1\text{ L}} = 0.0060\text{ mol NaOH}$$

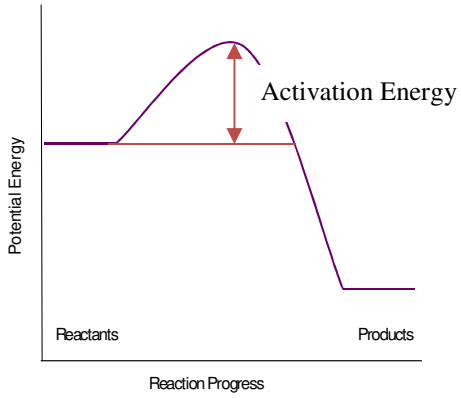
The stoichiometry requires 2 moles H_2SO_4 for every mole of NaOH. Therefore, we need:

$$0.0035\text{ mol } H_2SO_4 \times \frac{1\text{ mol NaOH}}{1\text{ mol } H_2SO_4} = 0.0070\text{ mol NaOH}$$

Since we need 0.0070 mol NaOH and we only have 00060 mol, the NaOH will run out and we will have some H_2SO_4 remaining. Since the acid is left over, the solution will be **acidic.**

Please write legibly! If I can't read it, I can't grade it!

15. Below is an unlabeled reaction coordinate diagram. (8 points)



a. Use the following terms to correctly label the diagram: Reaction Progress, Reactants, Products, Energy (4 points)

b. On the diagram, identify and label the activation energy for the reaction that converts reactants to products. (2 points)

c. How would a diagram appear for the same reaction, but with the use of a catalyst to increase the reaction rate? (2 points)

The position of the reactants and products would be the same, but the activation energy would decrease.

16. In a carbon-14 dating experiment, a fossil was found to have 3.13% of its natural abundance of carbon-14 (in other words, if it originally would have contained 100 g ^{14}C, it now only contains 3.13g ^{14}C). If the half-life of ^{14}C is 5730 years, how old is the fossil? (8 points)

$$\ln\left(\frac{N_t}{N_0}\right) = -0.693\frac{t}{t_{1/2}}$$

$$\ln\left(\frac{3.13}{100}\right) = -0.693\frac{t}{5730y}$$

$$-3.464 = -0.693\frac{t}{5730y}$$

$$t = 5730y\frac{-3.464}{-0.693} = \mathbf{28,600\ years\ old}$$

17. Hydrochloric acid (HCl) is classified as a strong acid, while acetic acid (CH_3COOH) is classified as a weak acid. Explain what these terms mean. If you could examine a solution of HCl and a separate solution of acetic acid on a molecular level, what would you expect to see in each? (8 points)

Strong acids dissociate completely, while weak acids do not. In a solution of HCl, we would expect to find only H^+ and Cl^-, but no "HCl".In a solution of CH_3COOH, we would expect to find H^+, CH_3COO^-, but also a significant amount of CH_3COOH. A diagram may be useful.

18. 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. (8 points)
    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?

$$9.00\times10^{14}\text{J} \times \frac{1\text{ mol}}{890\text{ kJ}} \times \frac{1\text{ kJ}}{1000\text{ J}} \times \frac{16\text{ g}}{1\text{ mol}} = 1.61\times10^{10}\text{ g methane}$$