1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 H 1.008																	2 He 4.003
3 Li 6.941	4 Be 9.012											5 B 10.81	6 C 12.01	7 N 14.01	8 O 16.00	9 F 19.00	10 Ne 20.18
11 Na 22.99	12 Mg 24.31											13 Al 26.98	14 Si 28.09	15 P 30.97	16 S 32.07	17 Cl 35.45	18 Ar 39.95
19 K 39.10	20 Ca 40.08	21 Sc 44.96	22 Ti 47.87	23 V 50.94	24 Cr 52.00	25 Mn 54.94	26 Fe 55.85	27 Co 58.93	28 Ni 58.69	29 Cu 63.55	30 Zn 65.38	31 Ga 69.72	32 Ge 72.64	33 As 74.92	34 Se 78.96	35 Br 79.90	36 Kr 83.80
37 Rb 85.47	38 Sr 87.62	39 Y 88.91	40 Zr 91.22	41 Nb 92.91	42 Mo 95.94	43 Tc (98)	44 Ru 101.07	45 Rh 102.91	46 Pd 106.42	47 Ag 107.87	48 Cd 112.41	49 In 114.82	50 Sn 118.71	51 Sb 121.76	52 Te 127.60	53 I 126.90	54 Xe 131.29
55 Cs 132.91	56 Ba 137.33	57 La 138.91	72 Hf 178.49	73 Ta 180.95	74 W 183.84	75 Re 186.21	76 Os 190.23	77 Ir 192.22	78 Pt 195.08	79 Au 196.97	80 Hg 200.59	81 Tl 204.38	82 Pb 207.20	83 Bi 208.98	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (267)	105 Db (268)	106 Sg (269)	107 Bh (270)	108 Hs (270)	109 Mt (278)	110 Ds (281)	111 Rg (282)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (290)	116 Lv (293)	117 Ts (294)	118 Og (294)

58 Ce 140.12	59 Pr 140.91	60 Nd 144.24	61 Pm (145)	62 Sm 150.36	63 Eu 151.96	64 Gd 157.25	65 Tb 158.93	66 Dy 162.50	67 Ho 164.93	68 Er 167.26	69 Tm 168.93	70 Yb 173.04	71 Lu 174.97
90 Th 232.04	91 Pa 231.04	92 U 238.03	93 Np (237)	94 Pu (244)	95 Am (243)	96 Cm (247)	97 Bk (247)	98 Cf (251)	99 Es (252)	100 Fm (257)	101 Md (258)	102 No (259)	103 Lr (266)

constants

$R = 0.08206$ L atm/mol K

$R = 8.314$ J/mol K

$N_A = 6.022 \times 10^{23}$ /mol

$h = 6.626 \times 10^{-34}$ J·s

$c = 3.00 \times 10^{8}$ m/s

$g = 9.81$ m/s^2

conversions

1 atm = 760 torr

1 atm = 101325 Pa

1 atm = 1.01325 bar

1 bar = 10^5 Pa

°F = °C(1.8) + 32

K = °C + 273.15

conversions

1 in = 2.54 cm

1 ft = 12 in

1 yd = 3 ft

1 mi = 5280 ft

1 lb = 453.6 g

1 ton = 2000 lbs

1 tonne = 1000 kg

1 gal = 3.785 L

1 gal = 231 in^3

1 gal = 128 fl oz

1 fl oz = 29.57 mL

water data

$C_{s,ice} = 2.09$ J/g °C

$C_{s,water} = 4.184$ J/g °C

$C_{s,steam} = 2.03$ J/g °C

$\rho_{water} = 1.00$ g/mL

$\rho_{ice} = 0.9167$ g/mL

$\rho_{seawater} = 1.024$ g/mL

$\Delta H_{fus} = 334$ J/g

$\Delta H_{vap} = 2260$ J/g

$K_w = 1.0 \times 10^{-14}$

This exam should have exactly 25 questions. Each question is equally weighted at 4 points each. Bubble in your answer choices on the bubblehseet provided. Your score is based on what you bubble on the bubblesheet and not what is circled on the exam.

---

1. Solution A has a pH equal to 7.6. Solution B has a hydrogen ion concentration, $[H^+]$, that is one million times higher. What is the pH of Solution B?

a. 6.6

b. 9.0

●c. 1.6

d. 13.6

e. 7.0

Explanation: The pH scale is a negative log scale. A solution with a hydronium ion concentration that is 1,000,000 times greater will be 6 units less than the other solution. This corresponds to pH = 1.6.

---

2. Identify the conjugate base of hydrocyanic acid, HCN?

a. H_2CN

●b. CN^-

c. HCNOH

d. H_2O

e. OH^-

Explanation: The conjugate base is the product of the deprotonation of the acid: CN^-.

---

3. Calculate the pH of 0.0022 M $Sr(OH)_2$.

●a. 11.64

b. 12.49

c. 2.66

d. 11.38

e. 2.36

Explanation: pH = 14 - pOH = 14 - (-log(.0022 × 2)) = 11.64

---

4. Which list contains all seven strong acids?

●a. HCl, HBr, HI, H_2SO_4, HNO_3, $HClO_3$, $HClO_4$

b. HCl, HBr, HI, HF, H_2SO_4, HNO_3, $HClO_3$

c. HCl, HBr, HF, H_2SO_4, HNO_3, $HClO_3$

d. HCl, HBr, HF, H_2SO_4, HNO_3, $HClO_4$

e. CH_3COOH, HBr, HF, HCN, HNO_3, $HClO_2$

Explanation: The strong acids are: HCl, HBr, HI, H_2SO_4, HNO_3, $HClO_3$, $HClO_4$

---

5. Which of the following is NOT a strong base?

●a. $Mg(OH)_2$

b. $Ca(OH_2$

c. $Sr(OH)_2$

d. LiOH

e. NaOH

f. CsOH

Explanation: Out of these choices, all are strong bases except $Mg(OH)_2$.

---

6. You are following the directions on setting up a brand new fish tank. Here are the first few steps:

1. Fill your fish tank with 75 gallons tap water

2. Measure the pH using provided pH strips

3. Add enough of the provided 0.036 M HCl until the pH strips indicate a pH = 7

If the initial pH measured in your 75 gallon tank was 9.50, what volume of the provided HCl solution is needed to reach pH = 7.00?

a. 3.1 gal

b. 15 gal

c. 6.6×10^{-7} gal

●d. 0.066 gal

e. 3.8 gal

Explanation: This is a neutralization reaction where $C_{H^+}V_{H^+} = C_{OH^-}V_{OH^-}$. Before you can plug this in, you must convert the pOH into $[OH^-] = 10^{-4.5}$. Now solve:

$$0.066\,\text{gal} = \frac{(10^{-4.5}\,\text{M})(75.0\,\text{gal})}{(0.036\,\text{M})}$$

---

7. A 0.050 M solution of lactic acid has a pH of 2.58. A 0.050 M solution of acrylic acid has a pH of 2.78. Which of these solutions has the greatest $[H^+]$?

●a. lactic acid

b. acrylic acid

c. You cannot tell from the information provided.

Explanation: Lactic acid has the lower pH and is therefore the stronger acid with the higher $[H^+]$.

---

8. Calculate the pH of a 0.0819 M $HClO_4$ solution.

a. 1.472

●b. 1.087

c. 0.081

d. 0.925

e. 8.529

Explanation: 1.087 = -log(.0.0819)

---

9. Which of the following chemical equations shows a salt dissolving in a neutral solution?

●a. $CaCl_2(s) \longrightarrow Ca^{2+}(aq) + 2Cl^-(aq)$

b. $HCl(s) \longrightarrow H^+(aq) + Cl^-(aq)$

c. $H_2O(\ell) \rightleftharpoons H^+(aq) + OH^-(aq)$

d. $NaCl(s) \longrightarrow NaCl(\ell)$

Explanation: The equation you're looking for should match a solid ionic compound dissolving into the aqueous phase:

$$CaCl_2(s) \longrightarrow Ca^{2+}(aq) + 2Cl^-(aq)$$

---

10. Consider the following chemical equation:

$$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

Is water acting as an acid or a base in this reaction?

a. base

●b. acid

c. neither

Explanation: Water is donating a proton here, meaning it is behaving as an acid.

---

11. A titration is performed by adding a strong base to fully neutralize a weak acid analyte. The titration is run exactly to the equivalence point (where there are equal moles of the strong base added and the initial moles of weak acid). The salt that is formed can be described as a...

●a. conjugate base

b. conjugate acid

c. strong base

d. strong acid

Explanation: The addition of a strong base to a weak acid forms a weak base salt that is the conjugate of the initial weak acid.

---

12. What is the $[OH^-]$ of an aqueous solution if $[H^+] = 1.16 \times 10^{-11}$ M?

a. 3.02×10^{-11} M

●b. 8.62×10^{-4} M

c. 1.16×10^{-25} M

d. 1.16×10^{-4} M

e. 6.12×10^{10} M

Explanation: Use $K_w = 10^{-14} = [H_3O^+][OH^-]$ to solve for $[OH^-]$:

$$8.62 \times 10^{-4} = \frac{10^{-14}}{1.16 \times 10^{-11}}$$

---

13. What is a role of limestone (calcium carbonate, $CaCO_3$) in lakes that is beneficial for aquatic life?

●a. dissolved limestone can resist changes in pH from acid rain

b. limestone can increase the pH of lakes by acting like a strong base

c. dissolved limestone will lower the pH to make lakes acidic

d. dissolved limestone can increase the pH of lakes by acting like a strong acid

Explanation: There are two pH values listed that are acidic: pH = 6.6 and pH = 2.7. If the pH = 2.7, it is way too low to sustain life. If the pH = 6.6, the ecosystem would be very mildly acidic and still capable of sustaining the majority of aquatic life.

---

14. Assume that each of the following acids are mixed at the same concentration of 0.15 mol/L. Which one will give the most acidic solution?

butanoic acid, $K_a = 1.5 \times 10^{-5}$

benzoic acid, $K_a = 6.4 \times 10^{-5}$

propanoic acid, $K_a = 1.3 \times 10^{-5}$

acrylic acid, $K_a = 5.6 \times 10^{-5}$

a. butanoic acid

●b. benzoic acid

c. propanoic acid

d. acrylic acid

e. All solutions have the same concentration and will therefore have the same acidity.

Explanation: The larger the value of K, the more products are formed. The highest K_a is benzoic acid, which is 6.4×10^{-5}. This will yield the most acid solution because more hydronium ion will be formed as a product.

---

15. A weak acid, HA, has a 9.85% ionization in a 0.085 M solution. What is the pH of this solution?

a. 1.01

●b. 2.08

c. 1.91

d. 2.73

e. 0.07

f. 0.78

Explanation: The H^+ concentration is equal to the percent ionization times the concentration. In other words, 9.85% of that .0.085 M solution will ionize. Then take the -log to get the pH.

$$2.08 = -\log(0.085 \times 0.0985)$$

---

16. Which of the following solutions is the most basic?

a. $[OH^-] = 1.0 \times 10^{-7}$ M

●b. $[OH^-] = 3.6 \times 10^{-3}$ M

c. $[OH^-] = 4.2 \times 10^{-4}$ M

d. $[OH^-] = 6.5 \times 10^{-9}$ M

Explanation: The more basic a solution, the higher the hydroxide ion concentration. The most basic choice is $[OH^-] = 3.6 \times 10^{-3}$.

---

17. Which of the following equations shows the conversion from the K_a of a weak acid to the K_b of its conjugate base?

a. $K_b = K_a \times Kw$

b. $K_b = K_a^2$

c. $K_b = \frac{K_a}{Kw}$

●d. $K_b = \frac{K_w}{Ka}$

Explanation: Rearrange $K_w = K_a K_b$ to $K_b = \frac{K_w}{Ka}$

---

18. The majority of weak electrolytes have which percent ionization?

a. 10% to 20%

●b. 1% or less

c. 30% to 50%

d. just below 100%

e. 60% to 75%

Explanation: The majority of all weak electrolytes ionize below 1%.

---

19. Which of the following lakes is most likely to sustain an abundance of plant and animal life?

a. Dallol hydrothermal lakes, pH = 2

b. Lake Natron, pH = 10.5

c. Lake Monoun, pH = 4.8

●d. Jenny Lake, pH = 6.8

e. Kawah Ijen, pH = 0.3

Explanation: Jenny Lake is the closest to neutral, meaning it is most likely the safest for the majority of aquatic life.

---

20. Which two strong acids might be found in droplets of acid rain?

●a. H_2SO_4 and HNO_3

b. H_2SO_4 and H_3PO_4

c. H_2SO_3 and HNO_2

d. HNO_3 and H_2CO_3

e. H_2S and NH_2

Explanation: Sulfur and nitrogen oxides react with water droplets and make sulfuric acid and nitric acid, H_2SO_4 and HNO_3.

---

21. What does it mean to say that a weak base (B_1) has a greater K_b than a second weak base (B_2) with an equal concentration?

●a. B_1 will produce more OH^- ions than B_2.

b. B_2 will produce a more basic solution than B_1.

c. B_2 must have a greater percent ionization than B_1.

d. The ratio of products to reactants for B_1 is less than it is for B_2.

Explanation: A larger K value will give more products. In this case, that will be a more basic solution and more hydroxide ions in the B_1 solution.

---

22. What is the pH of a weak base solution that has a percent ionization of 1.14% at 0.60 M?

●a. 11.84

b. 11.65

c. 13.83

d. 13.72

e. 9.45

Explanation: The provided percent ionization suggests that 1.14% of the 0.60 M ionizes to form $[OH^-]$. This is equal to 0.00684 M. Now convert this value into a pH by getting the pOH and then switching over to pH.

$$pOH = -\log(0.00684)$$

$$pH = 14 - pOH = 11.65$$

---

23. Topochico relies on dissolved carbon dioxide, CO_2, for its bubbles and flavor. Assuming nothing else is dissolved in the water besides the carbon dioxide, the pH of topochico is...

a. strongly acidic

●b. slightly acidic

c. equal to 7

d. slightly basic

e. strongly basic

Explanation: Carbon dioxide produces carbonic acid, a weak acid, in solution. This will produce a slightly acidic solution. Remember this is a beverage you want to drink. A strongly acidic solution would not be wise to drink.

---

24. Which of the following mixtures will result in a neutral pH solution?

a. mixing equal moles of weak acid and strong base

b. mixing equal moles of strong acid and weak base

●c. mixing equal moles of strong acid and strong base

d. mixing equal moles of weak acid and NaCl

Explanation: Running a complete neutralization between a strong acid and a strong base will result in a neutral solution.

---

25. Calculate the molarity of $[OH^-]$ when 1.6 grams of $Ca(OH)_2$ are fully dissolved in a 14 L solution. The molar mass of $Ca(OH)_2$ is 74 g/mol.

●a. 0.0031 M

b. 0.0016 M

c. 0.11 M

d. 0.22 M

e. 5.3 M

Explanation: Convert grams to moles and gallons to liter, and then divide to solve for molarity (mol/L).

0.0216216216 mol = 1.6 g / (74 g/mol)

Now double this: 0.0432432432432... mol OH^- in solution

and divide by volume = 0.06393811 M

Remember to bubble in ALL your answers BEFORE time is called. Double check your name, uteid, and version number before you turn in your bubblesheet. You must keep your exam for future reference. Please do not lose it. We will not replace it.