Periodic Table of the Elements

1A 1	2A 2	3B 3	4B 4	5B 5	6B 6	7B 7	8B 8	8B 9	8B 10	1B 11	2B 12	3A 13	4A 14	5A 15	6A 16	7A 17	8A 18
1 H 1.008																	2 He 4.00
3 Li 6.94	4 Be 9.01											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 95.96	43 Tc (98)	44 Ru 101.1	45 Rh 102.9	46 Pd 106.4	47 Ag 107.9	48 Cd 112.4	49 In 114.8	50 Sn 118.7	51 Sb 121.8	52 Te 127.6	53 I 126.9	54 Xe 131.3
55 Cs 132.9	56 Ba 137.3	57 La 138.9	72 Hf 178.5	73 Ta 180.9	74 W 183.8	75 Re 186.2	76 Os 190.2	77 Ir 192.2	78 Pt 195.1	79 Au 197.0	80 Hg 200.6	81 Tl 204.4	82 Pb 207.2	83 Bi 209.0	84 Po (209)	85 At (210)	86 Rn (222)
87 Fr (223)	88 Ra (226)	89 Ac (227)	104 Rf (261)	105 Db (262)	106 Sg (266)	107 Bh (264)	108 Hs (277)	109 Mt (268)	110 Ds (281)	111 Rg (281)	112 Cn (285)	113 Nh (286)	114 Fl (289)	115 Mc (289)	116 Lv (293)	117 Ts (293)	118 Og (294)

58 Ce 140.1	59 Pr 140.9	60 Nd 144.2	61 Pm (145)	62 Sm 150.4	63 Eu 152.0	64 Gd 157.3	65 Tb 158.9	66 Dy 162.5	67 Ho 164.9	68 Er 167.3	69 Tm 168.9	70 Yb 173.0	71 Lu 175.0
90 Th 232.0	91 Pa 231.0	92 U 238.0	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 (262)

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 20 questions. The questions are equally weighted at 5 points each. Bubble in your answer choices on the bubblesheet provided. Your score is based on what you bubble on the bubblesheet and not what is circled on the exam. Double check all information on the bubblesheet before you turn it in.

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1. Solution A has a hydronium ion concentration, $[H_3O^+]$, that is one thousand times higher than Solution B at identical temperature and pressure. Which of the following statements must be true?

● a. Solution A has a pH that is 3 units less than Solution B.

b. Solution A has a pH that is 3 units greater than Solution B.

c. Solution A has a pH that is 1/1000 times that of Solution B.

d. Solution A can have the same pH as Solution B.

Explanation: The pH scale is a negative log scale. A solution with a hydronium ion concentration that is 1000 times greater will be 3 units less than the other solution.

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2. Identify the conjugate base of formic acid, HCOOH?

a. H_2O

b. H_3O^+

c. OH^-

● d. $HCOO^-$

e. COO^{2-}

Explanation: The conjugate base is the product of the deprotonation of formic acid: $HCOO^-$.

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3. Calculate the pOH of 0.012 M $Ba(OH)_2$.

● a. 1.62

b. 12.4

c. 1.92

d. 12.1

e. 2.34

Explanation: $1.62 = -\log(0.012 \times 2)$

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4. Select the set of compounds which contains NO strong acids.

a. $Ca(OH)_2$, HI, CH_3COOH

b. CH_3COOH , HNO_3, $CaCO_3$

● c. $Ca(OH)_2$, HF, CH_3COOH

d. $CaCO_3$, NaCl, HCl

e. HBr, $HClO_4$, $CaCO_3$

Explanation: None of the following are strong acids: $Ca(OH)_2$, HF, CH_3COOH.

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5. When a person hyperventilates, the primary problem is not that they are inhaling too much oxygen. Rather, they are exhaling too much carbon dioxide, which can affect blood pH. The process of carbon dioxide dissolving in blood and dissociating as carbonic acid is shown in the steps below:

$$CO_2(g) \rightleftharpoons CO_2(aq)$$
$$H_2O(\ell) + CO_2(aq) \rightleftharpoons H_2CO_3(aq)$$
$$H_2CO_3(aq) \rightleftharpoons H^+(aq) + HCO_3^-(aq)$$

Select the answer that best describes the effect of exhaling too much carbon dioxide.

● a. blood pH increases

b. blood pH decreases

Explanation: The whole system above is in balance - equilibrium. If one hyperventilates, $CO_2(g)$ is removed too quickly thus shifting the equilibrium backwards (to the left). The reactions are all linked which means the 2nd and 3rd reactions also shift to the left. In the third reaction you can see that going to the left *removes* H+ from the solution (or blood in this case). Removal of H+ then drops the concentration and raises the pH.

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6. A salon wants to neutralize 55.0 gallons of water that have become contaminated with facial peel acids, resulting in a pH of 3.25. What volume of 0.015 M NaOH solution are needed to neutralize the acidic waste?

a. 3.09 gal

b. 0.0375 gal

c. 1.6×10^{-8} gal

●d. 2.06 gal

e. $1 \times 10^{-3.25}$ gallons

Explanation: This is a neutralization reaction where $C_{H^+}V_{H^+} = C_{OH^-}V_{OH^-}$. Before you can plug this in, you must convert pH into $[H^+] = 10^{-3.25}$. Now solve:

$$2.06\,\text{gal} = \frac{(10^{-3.25}\,\text{M})(55.0\,\text{gal})}{(0.0150\,\text{M})}$$

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7. A 0.020 M solution of citric acid has a pH of 2.46. A 0.020 M solution of ascorbic acid has a pH of 2.93. Which of these is the stronger acid?

●a. citric acid

b. ascorbic acid

c. You cannot tell from the information provided.

Explanation: Citric acid has the lower pH and is therefore the stronger acid.

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8. Calculate the pH of a 0.0337 M HNO_3 solution.

●a. 1.472

b. 0.0337

c. 5.599

d. 0.925

e. 8.529

Explanation: 1.472 = -log(.0037)

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9. How does water dissolve an ionic compound?

●a. The polarity of water allows the negative pole to surround cations and the positive pole to surround anions.

b. The polarity of water allows the negative pole to surround anions and the positive pole to surround cations.

c. The nonpolar nature of water allows the water molecules to surround a full ionic compound without separating the charged ions.

d. The nonpolar nature of water allows the water molecules to dissociate ionic compounds and non-selectively surround anions and cations.

Explanation: The polarity of water allows the negative pole to surround cations and the positive pole to surround anions.

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10. Water is amphiprotic, which means it can act as an acid and a base. Consider the following reaction:

$$HCl(aq) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + Cl^-(aq)$$

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

●a. base

b. acid

c. neither

Explanation: Water is accepting a proton here, meaning it is behaving as a base.

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11. A titration is performed by adding a strong acid to fully neutralize a weak base analyte. The titration is run exactly to the equivalence point (where there are equal moles of the strong acid added and the initial weak base solution). What is the generic reaction for this experiment?

●a. Strong Acid + Weak Base $\longrightarrow$ Weak Acid + Water

b. Strong Acid + Weak Base $\longrightarrow$ Weak Base + Water

c. Strong Acid + Weak Base $\longrightarrow$ Strong Acid + Water

d. Strong Acid + Weak Base $\longrightarrow$ Strong Base + Water

Explanation: The addition of a strong acid to a weak base forms a weak acid salt plus water.

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12. What is the $[OH^-]$ of an aqueous solution if $[H_3O^+] = 3.31 \times 10^{-4}$ M?

●a. 3.02×10^{-11} M

b. 3.31×10^{-4} M

c. 3.31×10^{-18} M

d. 3.02×10^{10} M

e. 6.12×10^{10} M

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

$$3.02 \times 10^{-11} = \frac{10^{-14}}{3.31 \times 10^{-4}}$$

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13. Which of the following pH values is slightly acidic but still capable of sustaining the majority of aquatic life?

●a. pH = 6.6

b. pH = 7.0

c. pH = 8.6

d. pH = 2.7

e. pH = 11.9

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.

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14. Assume that each of the following bases are mixed at the same concentration of 0.05 mol/L. Which one will give the most basic solution?

ammonia, $K_b = 1.8 \times 10^{-5}$

hydrazine, $K_b = 1.7 \times 10^{-6}$

methylamine, $K_b = 1.7 \times 10^{-9}$

ethylamine, $K_b = 5.6 \times 10^{-4}$

●a. ethylamine

b. ammonia

c. hydrazine

d. methylamine

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

Explanation: The larger the value of K, the more products are formed. The highest K_b is ethylamine, which is 5.6×10^{-4}. This will yield the most basic solution because more hydroxide will be formed as a product.

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15. A weak acid, HA, has a 2.5% ionization in a 0.10 M solution. What is the pH of this solution?

a. 0.0025

●b. 2.60

c. 1.00

d. 2.12

e. 5.24

f. 3.38

Explanation: The H^+ concentration is equal to the percent ionization times the concentration. In other words, 2.5% of that .10 M solution will ionize. This will be equal to .0025 M. Then solve for pH. 2.60 = -log(.0025).

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16. When pure water is carbonated with CO_2 gas the pH tends to rise slightly above 7 due to the alkaline nature of carbonate.

a. true

●b. false

Explanation: When CO_2 dissolves in water, it forms carbonic acid - thus making the water slightly acidic which means the pH is below 7.

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17. The K_a for nitrous acid (HNO_2) is 4.0×10^{-4}. What is the K_b for nitrite, NO_2^- ?

a. 4.0×10^{-18}

b. 2.0×10^{-8}

●c. 2.5×10^{-11}

d. 5.2×10^{-10}

e. 2.5×10^{3}

Explanation: $K_w = K_a K_b$

$$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{4.0 \times 10^{-4}}$$

$$K_b = \frac{K_w}{K_a} = 2.5 \times 10^{-11}$$

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18. Most weak acids and weak bases fall into which range of ionization given below when they are dissolved into water?

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 acids and bases ionize below 1%.

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19. When writing out the expression for an equilibrium constant, which of the species listed are left *out* of the expression?

a. gases

●b. solids

c. aqueous species

Explanation: Only gases (partial pressures) and aqueous species (molarities) are in equilibrium expressions. All solids and liquids drop out of the expression.

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20. Which of the following species can get into into the air and cause "acid rain"?

●a. sulfur oxides

b. carbon dioxide

c. methane

d. ozone

e. nitrogen

Explanation: Sulfur oxides react with water droplets and make sulfuric acid which is acid rain. Carbon dioxide merely makes water slightly acidic and does not fit the definition of "acid rain".

Remember to bubble in ALL your answers BEFORE time is called. Sign your bubblesheet AND your exam. Then turn in BOTH your exam copy and you bubblesheet.