Name _____   Block: _____   Date: _____

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Chemistry 12
ACID-BASE INDICATORS

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{KEY}

1. An indicator HInd is yellow in 0.1M NaOH and blue in 0.1M HCl. The pH range in which the colour change occurs in this indicator is 3.6 - 5.2.

    a) Write the *equilibrium equation* describing this indicator.

    $$HInd + H_2O \rightleftharpoons H_3O^+ + In^-$$
    blue   yellow

    b) What is the colour of HInd? **blue** What is the colour of Ind⁻? **yellow**

    c) What is the pH at the transition point of this indicator? **4.4** $\left(\frac{3.6+5.2}{2}\right)$

    d) What is the value of pKa for this indicator? **4.4**

    e) What is the Ka of this indicator? **4×10^{-5}** $(10^{-4.4})$

    f) At pH = 2.2, this indicator is the colour **blue** and [HInd] (>,<,=) **>** [Ind⁻].

    g) At pH = 7.0, this indicator is the colour **yellow** and [HInd] (>,<,=) **<** [Ind⁻].

    h) At pH = 11.3, this indicator is the colour **yellow** and [HInd] (>,<,=) **<** [Ind⁻].

    i) At pH = 4.4, this indicator is the colour **green** and [HInd] (>,<,=) **=** [Ind⁻].

    j) At pH = 4.3, this indicator is the colour **green** and [HInd] (>,<,=) **=** [Ind⁻].

    k) In 0.001M HNO₃, this indicator is the colour **blue** and [HInd] (>,<,=) **>** [Ind⁻].

    l) In 0.001M KOH, this indicator is the colour **yellow** and [HInd] (>,<,=) **<** [Ind⁻].

    m) At the *transition point*, is [H₃O⁺] = Ka (indicator.)? **yes**

2. A solution turns yellow when Orange IV is added and red when methyl orange is added. Give the approximate pH range of the solution.
    >2.8   <3.2

    2.8 - 3.2

3. A solution turns yellow when chlorophenol red is added and also yellow when methyl orange is added. Give the approximate pH range of the solution.
    <5.2   >4.4

    4.4 - 5.2

4. A solution turns magenta when phenolphthalein is added and yellow when alizarin yellow is added. Determine the approximate [H₃O⁺].
    >10.0   <10.1

    pH ≈ 10.05

    $[H_3O^+] = 10^{-10.05} = \boxed{9 \times 10^{-11} M}$

5.   A 0.10 M solution of a weak acid HX turns red in both chlorophenol red and in **>6.8**
     neutral red indicator. **<6.8**

     a)   Determine the approximate pH of this solution of HX.   **6.8**

     b)   Determine the Ka of the weak acid HX (<u>Not</u> the Ka (indicator)!)
          (Hint: Use an ICE table!)

$$HX + H_2O \rightleftharpoons X^- + H_3O^+$$

I	0.10		
C	-1.6×10^{-7}	$+1.6\times10^{-7}$	$+1.6\times10^{-7}$
E	$0.10-1.6\times10^{-7}$	1.6×10^{-7}	1.6×10^{-7}

$$Ka = \frac{(1.6\times10^{-7})^2}{(.10-1.6\times10^{-7})}$$

$$Ka = 2.5\times10^{-13}$$

$$[H_3O^+] = 10^{-6.8}$$
$$= 1.6\times10^{-7} M$$

$$\boxed{Ka = 3\times10^{-13}}$$

6.   An indicator "Gupta Green" (HGg) turns yellow when $[H_3O^+]$ drops below
     1.2×10^{-4} M and turns blue when $[H_3O^+]$ rises above 1.8×10^{-3} M. (Notice 2 SD's)

     a)   Find the pH range over which the indicator changes colour.(2SD's)
$$pH = -\log(1.2\times10^{-4}) = 3.92$$
$$pH = -\log(1.8\times10^{-3}) = 2.74$$
     blue   **yellow**
     $$2.74 < pH < 3.92$$

     b)   Determine the pKa of the indicator "Gupta Green".   **3.33**

     pH = 3.72
     c)   What colour would 0.00019 M HCl be in this indicator?   **green**
     pOH = 2.00   pH = 12.00
     d)   What colour would 0.010 M NaOH be in this indicator?   **yellow**

     e)   What colour would 0.10 M CH_3COOH be in this indicator?
          (Show how you got $[H_3O^+]$)

$$CH_3COOH + H_2O \rightleftharpoons H_3O^+ + CH_3COO^-$$

I	0.10		
C	$-x$	$+x$	$+x$
E	$0.10-x$	x	x

assume
$0.10-x \approx 0.10$

$$Ka = \frac{x^2}{0.10} \qquad Ka = 1.8\times10^{-5}$$

$$x = \sqrt{0.10\,(1.8\times10^{-5})}$$

$$x = 1.34\times10^{-3} = [H_3O^+]$$

$$pH = -\log 1.34\times10^{-3} = \boxed{2.87 = pH}$$

7.   An indicator HInd turns yellow in 0.10 M HCl and blue in 0.10 M NaOH.

   a) Write the equation describing the **equilibrium** in HInd.

$$HIn + H_2O \rightleftharpoons H_3O^+ + In^-$$
        yellow   **blue**

     b) What colour is HInd? **yellow** What colour is Ind⁻? **blue**

c) HInd is green in the range pH = 5.4 to pH = 6.2. Determine the Ka of HInd.(1)

$pKa = 5.8$ $Ka = 10^{-5.8} = \boxed{2 \times 10^{-6}}$

midpoint

d) When a few drops of HInd are added to a weak acid HA_1, the colour is yellow. Which is the stronger acid, HInd or HA_1?

$$HA_1 + In^- \rightleftharpoons HIn + A_1^-$$

blue   yellow HA_1 is stronger
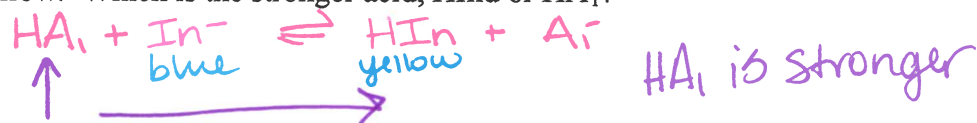
e) When a few drops of HInd are added to a weak acid HA_2, the colour is blue. Which is the stronger acid, HInd or HA_2?

$$HA_2 + In^- \rightleftharpoons HIn + A_2^-$$

blue   yellow   HInd is stronger
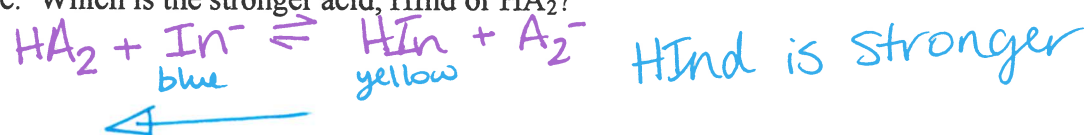
f) Which acid is stronger, HA_1, or HA_2? HA_1

g) List the acids HInd, HA_1 and HA_2 in order of strength from strongest to weakest.

HA_1 > $HInd$ > HA_2

h) List the bases Ind⁻, A_1^-, and A_2^-, in order of strength from strongest to weakest.

A_2^- > Ind^- > A_1^-