P G7 Just what is that solution in front of me, a buffer?

For the following combinations will the pH be 7, above 7, or below 7? Buffer or not? Justify.

Guesstimate pH of resulting solutions. *NO CALCULATORS*

Equilibrium Constants for H_3PO_4

K_{a1}	7.5×10^{-3}
K_{a2}	6.2×10^{-8}
K_{a3}	4.2×10^{-13}

Equilibrium Constants

K_a or K_b as appropriate for the listed substance.

HCN	$K_a = 4.9 \times 10^{-10}$
HF	$K_a = 3.5 \times 10^{-4}$
$HC_2H_3O_2$	$K_a = 1.8 \times 10^{-5}$
Al^{3+}	$K_a = 1.5 \times 10^{-5}$
NH_3	$K_b = 1.8 \times 10^{-5}$
$(C_2H_5)_2NH$	$K_b = 1.3 \times 10^{-3}$

a. equal volumes of 1 M KCl and 1 M HCl

b. equal volumes of 1 M HF and 1 M HCl

c. equal volumes of 1 M $HC_2H_3O_2$ and 1 M $NaC_2H_3O_2$

d. equal volumes of 1 M HF and 0.5 M NaOH

e. equal volumes of 1 M NH_3 and 1 M NH_4NO_3

f. 50 ml of 1 M NH_3 and 25 of 1 M HNO_3

g. 50 ml of 1 M NaOH and 25 of 1 M HNO_3

h. 100 ml of 1 M NH_3 and 50 ml of 1 M NaOH

i. equal volumes of 1 M NaBr and 1 M KCl

j. equal volumes of 1 M KOH and 1 M $HClO_4$

k. equal volumes of 1 M CsOH and 1 M HF

l. equal volumes of 1 M $HC_2H_3O_2$ and 2 M NaOH

m. equal volumes of 1 M CsF and 2 M HCl

n. equal volumes of 1 M H_3PO_4 and 1 M NaOH

o. equal volumes of 1 M NaH_2PO_4 and 1 M Na_2HPO_4

P G7 Just what is that solution in front of me, a buffer? *ANSWERS*

2. For the following combinations will the pH be 7, above 7, or below 7? Buffer or not? Justify.

The trick to the following questions is to be on the lookout for the SA "pathetics," negative ions of SA (Cl^-, Br^-, I^-, NO_3^-, SO_4^-, ClO_4^-, ClO_3^-), and the SB pathetics, Group 1 & 2 positive ions (Li^+, Na^+, K^+, Rb^+, Cs^+, Ba^{2+}, Sr^{2+}, Ca^{2+}).
If you know who the pathetics are, then all other positive ions are conjugate weak acids, and (nearly) all other negative ions are conjugate weak bases.

a. equal volumes of 1 M KCl and 1 M HCl

KCl is made of two pathetic ions, and HCl is a SA. Thus this is NOT a buffer and is has a pH below 7. Lots of acid

b. equal volumes of 1 M HF and 1 M HCl

HF is a WA, and HCl is a SA, thus this is nothing more than lots of acid; NOT a buffer, just pH below 7. Lots of acid

c. equal volumes of 1 M $HC_2H_3O_2$ and 1 M $NaC_2H_3O_2$

$HC_2H_3O_2$ is a WA, and for $NaC_2H_3O_2$, the Na^+ is a pathetic and the $C_2H_3O_2^-$ is the conjugate WB of the WA, $HC_2H_3O_2$. Since both the WA and WB are present in equal quantities, this is a buffer with pH below 7. The pH will be ~4ish ~pK_a

d. equal volumes of 1 M HF and 0.5 M NaOH

HF is a WA, and NaOH is a SB. Look at the molarities to se that the SB will neutralize half the WA, thus half of the WA will be left, and half of the WA, HF, will turn into WB, F^-. This is an acidic buffer with pH below 7. The pH will be ~3ish ~ pK_a

e. equal volumes of 1 M NH_3 and 1 M NH_4NO_3

NH_3 is a WB, and NH_4NO_3 is a pathetic, NO_3^-, and the conjugate WA, NH_4^+, of the WB, NH_3. Since both the WB and WA are present in equal quantities, this is a basic buffer with pH above 7. The pH will be ~9ish 14 − pK_b

f. 50 ml of 1 M NH_3 and 25 of 1 M HNO_3

NH_3 is a WB, and HNO_3 is a SA. Since the SA will neutralize half the WB, half of the WB will be left, and half of the WB will turn into WA. This is a basic buffer with pH above 7. The pH will be ~9ish 14 − pK_b

g. 50 ml of 1 M NaOH and 25 of 1 M HNO_3

NaOH is a SB and HNO_3 is a SA. We have twice as much base as acid, but since there is no WA and no WB, this is NOT a buffer. It is simply more SB present than SA, thus the pH will be above 7.

h. 100 ml of 1 M NH_3 and 50 ml of 1 M NaOH

NH_3 is a WB, and NaOH is a SB, thus this is nothing more than lots of base; NOT a buffer, just pH above 7.

i. equal volumes of 1 M NaBr and 1 M KCl

NaBr is made of two pathetic ions, Na^+ and Br^-, and KCl is also made out of two pathetics, K^+ and Cl^-. Thus this is NOT a buffer just lots of non-hydrolyzing ions, thus the pH is 7.

j. equal volumes of 1 M KOH and 1 M $HClO_4$

KOH is made of a SB, and $HClO_4$ is a SA. Since the SA and SB are present in equal quantities, neutralization occurs (H_2O is formed) and all that remains are non-hydrolyzing ions (K^+ and ClO_4^-) thus the pH is 7.

k. equal volumes of 1 M CsOH and 1 M HF

CsOH is made of a SB, and HF is a WA. Since the SB and WA are present in equal quantities, neutralization occurs (H_2O is formed) and what remains in the beaker is a pathetic, Cs^+, and a **WB, F^-**, thus the pH is above 7.

l. equal volumes of 1 M $HC_2H_3O_2$ and 2 M NaOH

$HC_2H_3O_2$ is made of a WA, and NaOH is a SB. Since the SB is present in twice the quantity needed to neutralize the WA, there is lots of excess SB left over, thus the solution will NOT be a buffer with a pH above 7.

m. equal volumes of 1 M CsF and 1 M HCl

CsF is made of a pathetic and a WB, and HCl is a SA. Since the WB and SA are present in equal quantities, neutralization occurs (H_2O is formed) and what remains in the beaker is are two pathetics, Cs^+ and Cl^-, and a WA, HF. Thus the pH is below 7.

n. equal volumes of 1 M H_3PO_4 and 1 M NaOH

H_3PO_4 is made of a WA, and NaOH is a SB. Since enough SB is present to neutralize one of the ionizable H^+ ions, $H_2PO_4^-$, will remain in the beaker. This is a WA, with very little of it's conjugate WB present and is thus NOT a buffer, but will be acidic with a pH below 7.

o. equal volumes of 1 M NaH_2PO_4 and 1 M Na_2HPO_4

NaH_2PO_4 is made of a pathetic, Na^+, and a WA, $H_2PO_4^-$. Na_2HPO_4 is a is a pathetic, Na^+, and a WB, HPO_4^{2-} (the WB of $H_2PO_4^-$). This is a buffer, and would likely have a pH ~7ish, the pK_a of the WA, $H_2PO_4^-$.