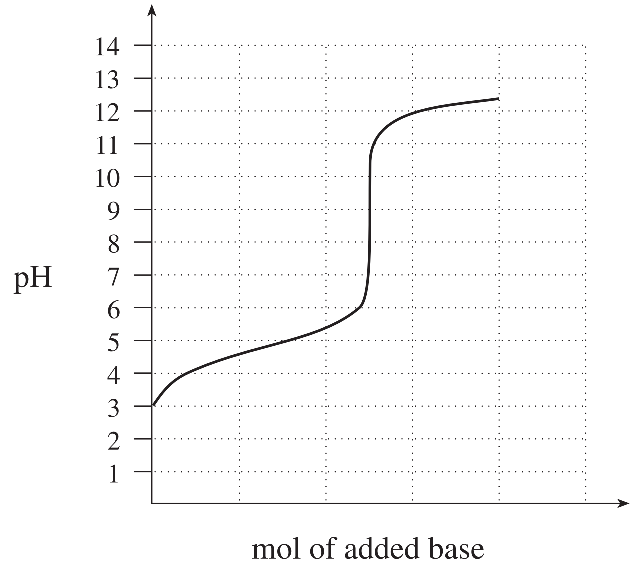
59. Consider the following titration curve:



Select a suitable indicator for this titration.

A. orange IV
B. methyl red
C. thymolphthalein
D. indigo carmine

60. Calculate the volume of 0.300 M HNO_3 needed to completely neutralize 25.0 mL of 0.250 M $Sr(OH)_2$.

A. 10.4 mL
B. 15.0 mL
C. 20.8 mL
D. 41.7 mL

61. Equal moles of which of the following chemicals could be used to make a basic buffer solution?

A. HF and NaOH
B. HCl and NaCl
C. KBr and $NaNO_3$
D. NH_3 and NH_4Cl

62. Which reaction occurs when calcium oxide is added to water?

A. $2CaO_{(s)} \rightarrow Ca_2O_{2(aq)}$
B. $2CaO_{(s)} \rightarrow 2Ca_{(aq)} + O_{2(aq)}$
C. $CaO_{(s)} + H_2O_{(\ell)} \rightarrow Ca(OH)_{2(aq)}$
D. $CaO_{(s)} + H_2O_{(\ell)} \rightarrow CaOH_{(aq)} + O_{2(aq)}$

63. A chemical indicator in solution consists of

A. a weak acid and its conjugate acid.
B. a weak acid and its conjugate base.
C. a strong acid and its conjugate acid.
D. a strong acid and its conjugate base.

64. A chemical indicator has a transition point at a $\text{pOH} = 8.0$. Calculate its K_a value and identify the indicator.

A. $K_a = 1 \times 10^{-8}$, phenol red
B. $K_a = 1 \times 10^{-6}$, methyl red
C. $K_a = 1 \times 10^{-8}$, thymol blue
D. $K_a = 1 \times 10^{-6}$, chlorophenol red

65. In acid-base titrations, the solution of known concentration is called a(n)

A. basic solution.
B. acidic solution.
C. standard solution.
D. indicating solution.

66. During a titration, $25.0\,\text{mL}$ of $H_3PO_{4(aq)}$ is completely neutralized by $42.6\,\text{mL}$ of $0.20\,\text{M}$ $NaOH$. Calculate the concentration of the acid.

A. $0.11\,\text{M}$
B. $0.17\,\text{M}$
C. $0.34\,\text{M}$
D. $1.0\,\text{M}$

67. Write the net ionic equation for the neutralization of $HF_{(aq)}$ with $Sr(OH)_{2(aq)}$.

A. $HF_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)} + F^-_{(aq)}$
B. $HF_{(aq)} + H_2O_{(\ell)} \rightarrow H_3O^+_{(aq)} + F^-_{(aq)}$
C. $2HF_{(aq)} + Sr(OH)_{2(aq)} \rightarrow SrF_{2(aq)} + 2H_2O_{(\ell)}$
D. $2H^+_{(aq)} + 2F^-_{(aq)} + Sr^{2+}_{(aq)} + 2\,OH^-_{(aq)} \rightarrow SrF_{2(aq)} + 2H_2O_{(\ell)}$

68. Consider the buffer equilibrium:

$$\underset{\text{high concentration}}{HNO_{2(aq)}} + H_2O_{(\ell)} \rightleftarrows \underset{\text{low concentration}}{H_3O^+_{(aq)}} + \underset{\text{high concentration}}{NO_2^-{}_{(aq)}}$$

What happens when a small amount of $HCl_{(aq)}$ is added to the equilibrium system?

A. The pH increases slightly.
B. The pH decreases slightly.
C. The equilibrium shifts to the right.
D. The equilibrium does not shift due to the levelling effect.

69. The indicator phenol red will be red in which of the following solutions?

A. 1.0 M HF
B. 1.0 M HBr
C. 1.0 M NH_4Cl
D. 1.0 M Na_2CO_3

70. Which of the following chemical indicators has a $K_a = 2.5 \times 10^{-5}$?

A. methyl orange
B. phenolphthalein
C. thymolphthalein
D. bromcresol green

71. *At a certain point in a strong acid-strong base titration, the moles of* H^+ *are equal to the moles of* OH^-. This is a definition of which of the following?

A. the end point
B. the titration point
C. the transition point
D. the equivalence point

72. A 25.0 mL sample of $H_2SO_{4(aq)}$ is titrated with 15.5 mL of 0.50 M $NaOH_{(aq)}$. What is the concentration of the $H_2SO_{4(aq)}$?

A. 0.078 M
B. 0.16 M
C. 0.31 M
D. 0.62 M

73. What is the complete ionic equation for the neutralization of $0.1\,M\ Sr(OH)_{2(aq)}$ with $0.1\,M\ H_2SO_{4(aq)}$?

A. $H^{+}_{(aq)} + OH^{-}_{(aq)} \rightarrow H_2O_{(\ell)}$

B. $Sr^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow SrSO_{4(s)}$

C. $Sr^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} + 2H^{+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow SrSO_{4(s)} + 2H_2O_{(\ell)}$

D. $Sr^{2+}_{(aq)} + 2\,OH^{-}_{(aq)} + 2H^{+}_{(aq)} + SO_4{}^{2-}_{(aq)} \rightarrow Sr^{2+}_{(aq)} + SO_4{}^{2-}_{(aq)} + 2H_2O_{(\ell)}$

74. Carbon dioxide gas in the atmosphere dissolves in normal rainwater. This causes normal rainwater to

A. be slightly basic.
B. have a pH slightly less than 7.0 .
C. be unaffected and remain neutral.
D. have a pH slightly greater than 7.0 .

75. What is true about the transition point of all indicators described by the following equilibrium:

$$HIn + H_2O \rightleftarrows H_3O^+ + In^-$$

A. $pH = K_a$

B. $[HIn] = [In^-]$

C. $[H_3O^+] = 1.0 \times 10^{-7}\ M$

D. moles of H_3O^+ equals moles of OH^-

76. A chemical indicator has a $K_a = 4.0 \times 10^{-6}$. What is the pH at the transition point and the identity of the indicator?

	pH	Indicator
A.	5.4	methyl red
B.	5.4	bromcresol green
C.	8.6	phenolphthalein
D.	8.6	thymol blue

77. A 20.0 mL sample of HCl is titrated with 25.0 mL of 0.20 M $Sr(OH)_2$. What is the concentration of the acid?

A. 0.13 M
B. 0.20 M
C. 0.25 M
D. 0.50 M

78. Which of the following is the net ionic equation for the neutralization of $HNO_{3(aq)}$ with $Sr(OH)_{2(aq)}$?

A. $H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(\ell)}$
B. $Sr^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} \rightarrow Sr(NO_3)_{2(s)}$
C. $2HNO_{3(aq)} + Sr(OH)_{2(aq)} \rightarrow Sr(NO_3)_{2(aq)} + 2H_2O_{(\ell)}$
D. $2H^+_{(aq)} + 2NO_3^-{}_{(aq)} + Sr^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Sr^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2H_2O_{(\ell)}$

79. When a strong acid is titrated with a strong base, what will the pH value be at the equivalence point?

A. 0.0
B. 6.8
C. 7.0
D. 8.6

80. Which of the following acids could **not** be present in a buffer solution?

A. HF
B. HNO_2
C. H_2SO_3
D. $HClO_4$

Written

1. A titration was performed by adding 0.115 M NaOH to a 25.00 mL sample of H_2SO_4. Calculate the $[H_2SO_4]$ from the following data. **(3**

	Trial #1	Trial #2	Trial #3
Initial volume of NaOH (mL)	4.00	17.05	8.00
Final volume of NaOH (mL)	17.05	28.00	19.05

2. A titration was performed by adding $0.175\,M\ H_2C_2O_4$ to a $25.00\,mL$ sample of NaOH. The following data was collected:

	Trial #1	Trial #2	Trial #3
Final volume of $H_2C_2O_4$ (mL)	23.00	39.05	20.95
Initial volume of $H_2C_2O_4$ (mL)	4.85	23.00	5.00

a) Calculate the [NaOH]. **(3 marks)**

b) Explain why the pH at the equivalence point is greater than 7.

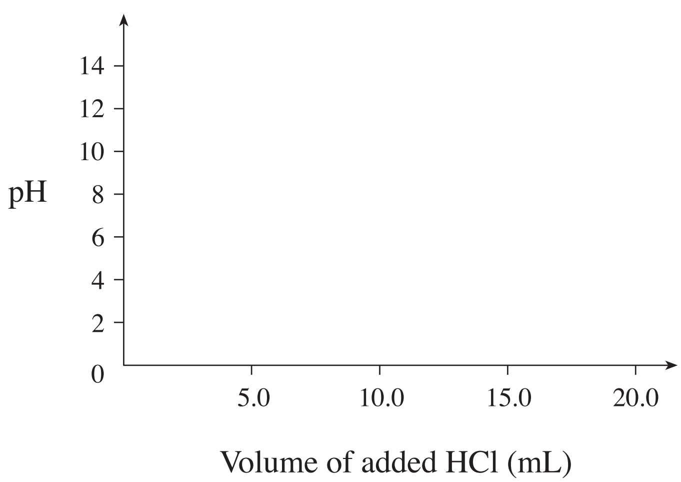
3. A $250.0\,mL$ sample of HCl with a pH of 2.000 is completely neutralized with $0.200\,M$ NaOH.

a) What volume of NaOH is required to reach the stoichiometric point?

b) Write the net ionic equation for the above neutralization reaction.

c) If the HCl were titrated with a $0.200\,M\ NH_{3(aq)}$ instead of $0.200\,M$ NaOH, how would the volume of base required to reach the equivalence point compare with the volume calculated in part a) ? Explain your answer.

4. a) In the space below, sketch the titration curve for the reaction when $0.10\,M$ HCl is added to $10.0\,mL$ of $0.10\,M$ NaOH.



b) Describe two changes in the titration curve that would result from using $0.10\,M\ CH_3COOH$ in place of the HCl.

5. Calculate the $[OH^-]$ in $0.50\,M\ NH_{3(aq)}$.

6. An indicator is often used during acid-base titrations.

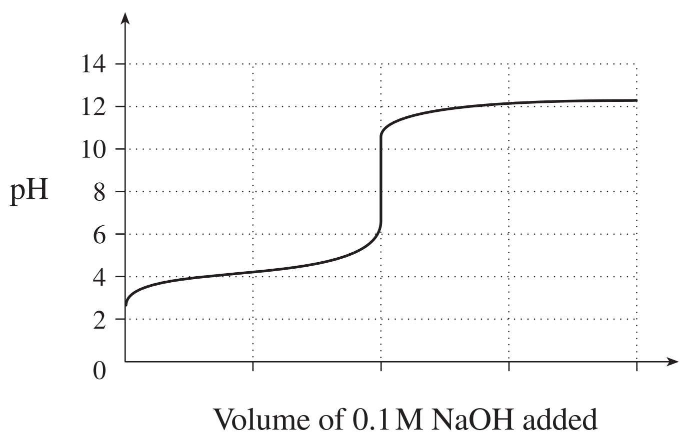
a) Define the term *transition point* for an indicator.

b) Calculate the K_a value for methyl red.

c) A mixture of indicators is made by combining equal amounts of methyl orange and bromthymol blue. Complete the following table, showing the colour of each indicator and the mixture at pH of 5 and pH of 9.

	Colour of methyl orange	Colour of bromthymol blue	Colour of mixture
pH=5			
pH=9			

7. A $0.1\,M$ unknown acid is titrated with $0.10\,M$ NaOH and the following titration curve results:



a) Choose a suitable indicator (other than phenolphthalein) and give a reason for your choice.

b) Is the unknown acid weak or strong? Explain.

Multiple-Choice Answers

1	B	6	C	11	A	16	B	21	C	26	A	31	D	36	B	41	A	46	A
2	D	7	C	12	D	17	C	22	D	27	A	32	A	37	D	42	D	47	A
3	C	8	C	13	B	18	B	23	D	28	C	33	A	38	A	43	D	48	D
4	D	9	C	14	C	19	B	24	A	29	B	34	C	39	D	44	D	49	C
5	D	10	D	15	A	20	B	25	A	30	B	35	B	40	B	45	B	50	B

51	C	56	B	61	D	66	A	71	D	76	A	81		86		91		96	
52	D	57	B	62	C	67	A	72	B	77	D	82		87		92		97	
53	D	58	B	63	B	68	B	73	C	78	A	83		88		93		98	
54	D	59	C	64	D	69	D	74	B	79	C	84		89		94		99	
55	B	60	D	65	C	70	D	75	B	80	D	85		90		95		100	

Solutions to Written

1. $2NaOH + H_2SO_4 \rightleftarrows Na_2SO_4 + 2H_2O$

$$\text{vol of NaOH} = 11.00\text{ mL}$$

$$\text{mol NaOH} = 0.01100\text{ L}(0.115\text{ mol/L}) = 1.265 \times 10^{-3}\text{ mol}$$

$$\text{mol } H_2SO_4 = \tfrac{1}{2}\left(1.265 \times 10^{-3}\text{mol NaOH}\right) = 6.325 \times 10^{-4}\text{ mol}$$

$$[H_2SO_4] = \frac{6.325 \times 10^{-4}\text{ mol}}{0.02500\text{ L}} = 0.0253\text{ M}$$

2. a) $H_2C_2O_4 + 2NaOH \rightarrow Na_2C_2O_4 + 2H_2O$

$$\text{vol } H_2C_2O_4 = 16.00\text{ mL}$$

$$\text{mol } H_2C_2O_4 = 0.01600\text{ L}(0.175\text{ mol/L}) = 2.800 \times 10^{-3}\text{ mol}$$

$$\text{mol NaOH} = 2 \times \text{mol } H_2C_2O_4 = 5.600 \times 10^{-3}\text{ mol}$$

$$[\text{NaOH}] = \frac{5.600 \times 10^{-3}\text{ mol}}{0.02500\text{ L}} = 0.224\text{ M}$$

b) The $C_2O_4^{2-}$ ion resulting from the dissociation of $Na_2C_2O_4$ hydrolyzes to form a basic solution.

3. a) $H_3O^+ + OH^- \rightleftarrows 2H_2O$

$$[HCl] = 1.00 \times 10^{-2}\ M$$

$$\text{mol HCl} = (0.250\ L)\left(1.00 \times 10^{-2}\ \text{mol/L}\right)$$

$$= 2.50 \times 10^{-3}\ \text{mol}$$

$$\text{mol HCl} = \text{mol NaOH}$$

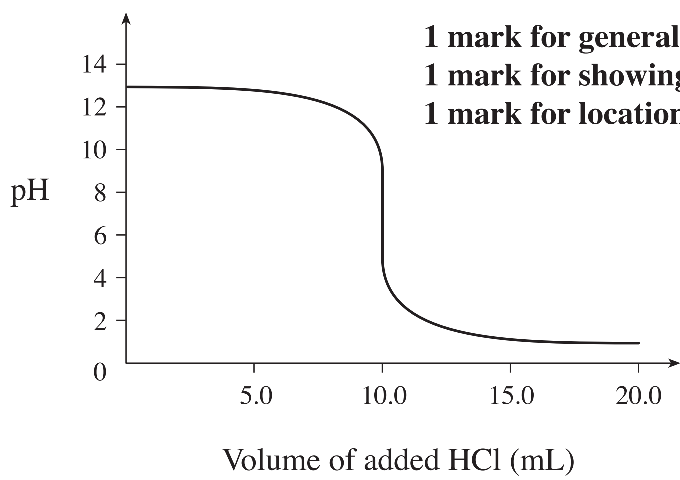
$$\text{Volume of NaOH} = \frac{2.50 \times 10^{-3}\ \text{mol}}{0.200\ M} = 1.25 \times 10^{-2}\ L$$

b)

c) The volume of base required would not change,

because the strong acid results in the reaction going to completion in a 1:1 ratio.

4. a) In the space below, sketch the titration curve for the reaction when 0.10 M HCl is added to 10.0 mL of 0.10 M NaOH.



1 mark for general shape
1 mark for showing curve drop
1 mark for location of equivalence point

b) *Any **two** of the following for **1 mark** each.*

The equivalence point is > 7.
The vertical part of the curve is shorter.
Buffer region.

5. $$K_b = \frac{K_w}{K_a} = \frac{1.0 \times 10^{-14}}{5.6 \times 10^{-10}} = 1.79 \times 10^{-5}$$

	NH_3	+	H_2O	$\rightleftarrows$	NH_4^+	+	OH^-
[I]	0.50				0		0
[C]	$-x$				$+x$		$+x$
[E]	$0.50 - x$				x		x

$$K_b = \frac{[NH_4^+][OH^-]}{[NH_3]} = \frac{(x)(x)}{(0.50 - x)} = 1.79 \times 10^{-5}$$

Use assumption that $0.50 - x \approx 0.50$ or use the quadratic formula.

$$x = [OH^-] = 3.0 \times 10^{-3}\ M$$

6. a) The point where the indicator is halfway through the colour change.

OR

$$[HInd] = [Ind^-]$$

b)
$$\text{Average pH} = \frac{4.8 + 6.0}{2} = 5.4$$

$$K_a = 1 \times 10^{-5.4}$$

$$= 4 \times 10^{-6}$$

c)

	Colour of methyl orange	Colour of bromthymol blue	Colour of mixture
pH=5	yellow	yellow	yellow
pH=9	yellow	blue	green

7. a) Suitable Indicator: Thymol blue

Reason:

- The transition point is close to the equivalence point.

b) Unknown Acid: Weak

For example any* one *of the following for* 1 mark *each:

Explanation:

- the shape of the curve is characteristic of a weak acid being titrated with a strong base
- the initial pH is greater than 1.0
- the pH at the equivalence point is greater than 7.0