Chemistry 12
Worksheet 4-6
Anhydrides, Acid Rain and Titrations

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Name KEY

Date Due _____

Correct & Hand In by _____

This worksheet covers material from class notes and Student Workbook pages 154-158, and pages 186-188.

1. State whether the following compounds will act as acids (A) or bases (B) when added to water. (10 marks)

(10)

a) ClO_2 ..... A
b) SrO ..... B
c) Cr_2O_3 ..... B
d) SeO_2 ..... A
e) NO_2 ..... A
f) CO_2 ..... A
g) Cs_2O ..... B
h) BaO ..... B
i) SO_3 ..... A
j) Ag_2O ..... B

2. a) Define a **basic anhydride** (1 mark) - an oxygen containing compound which reacts with water to form a basic solution (OH^-).

(1)

b) Give three examples of basic anhydrides (*make sure formulas are correct!*) (3 marks)

(3) BaO Na_2O ZnO etc.

3. a) Define an **acidic anhydride** (1 mark) - an oxygen containing compound which reacts with water to form an acidic solution (H_3O^+)

(1)

b) Give three examples of acidic anhydrides (*make sure formulas are correct!*) (3 marks)

(3) SO_2 Cl_2O CO_2 etc.

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4. Give three examples of *amphoteric* (or amphiprotic) anhydrides.(3 marks)

(3) Al_2O_3 Ga_2O_3 GeO_2

(1) The element other than oxygen in these is found near the staircase of the periodic table.(1 mark)

5. Normal (unpolluted) rain water usually has a pH of about 5.6. This is

(2) less than 7 due to CO_2 gas dissolving in the air.(2 marks)

(1) 6. "Acid rain" could be defined as rain having a pH below 5.6. (1 mark)

(1) 7. Fossil fuels containing the element sulphur are a major cause of acid rain. (1 mark)

8. Give two formula equations which show how sulphurous acid can be produced starting with sulphur. (2 marks)

(2) 1. $S + O_2 \rightarrow SO_2$

2. $SO_2 + H_2O \rightarrow H_2SO_3$

9. Give three formula equations which show how sulphuric acid can be produced starting with sulphur. (3 marks)

(3) 1. $S + O_2 \rightarrow SO_2$

2. $2SO_2 + O_2 \rightarrow 2SO_3$

3. $SO_3 + H_2O \rightarrow H_2SO_4$

(1) 10. The element nitrogen reacts with oxygen in the cylinders of automobile motors to produce various nitrogen oxides. (1 mark)

(1) 11. Give the balanced equation for the formation of NO from it's elements. (1 mark)

$N_2 + O_2 \rightarrow 2NO$

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12. Give the balanced equation for the formation of NO_2 from it's elements. (1 mark)

(1)

$N_2 + 2O_2 \rightarrow 2NO_2$

13. Give the balanced equation for the formation of nitrous and nitric acid from NO_2 dissolving in rain water. (1 mark)

(1)

$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$

14. Other than cars and fossil fuel burning power plants, what are some other sources of acid rain? (2 marks)

(2)

lightning, volcanoes

15. Explain why acid rain falling on one area may do less damage than the same acid rain falling in a different area. (1 mark)

(1)

Some areas have soils and rock which can neutralize acids eg) $CaCO_3$, $MgCO_3$

16. Give four major unfavourable effects of acid rain. (4 marks)

(4)

1. aquatic life affected
2. forests weakened
3. minerals (eg. Al^{3+}) leached out of topsoil (toxic to fish & plants)
4. metals & stone buildings or statues corroded.

17. Give four ways in which acid rain and the problems associated with it could be solved or at least helped (4 marks)

(4)

1. International agreements to limit sulphur in fuels and NO_x in car exhaust.
2. Alternate, less polluting energy sources (wind geothermal etc)
3. Modernization of industrial processes
4. Devices to remove harmful substances from smokestacks (scrubber)

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18. 13.45 mL of 0.200 M NaOH is required to titrate 25.0 mL of a solution which is known to have HCl. Calculate the original [HCl]. Show all your steps. (3 marks)

mol NaOH: $= 0.200\,M \times 0.01345\,L = 0.00269\,mol\ NaOH$

(3) $NaOH + HCl \rightarrow H_2O + NaCl$

mol HCl: $0.00269\,mol\ NaOH \times \frac{1\,mol\ HCl}{1\,mol\ NaOH} = 0.00269\,mol\ HCl$

$[HCl] = \frac{0.00269\,mol\ HCl}{0.0250\,L\ HCl} = \boxed{0.108\,M}$

19. 13.45 mL of 0.200 M HCl is required to titrate 25.0 mL of a solution which is known to have $Ba(OH)_2$. Calculate the original $[Ba(OH)_2]$. Show all your steps. (3 marks)

mol HCl: $0.200\,M \times 0.01345\,L = 0.00269\,mol\ HCl$

(3) $2HCl + Ba(OH)_2 \rightarrow 2H_2O + BaCl_2$

mol $Ba(OH)_2$: $0.00269\,mol\ HCl \times \frac{1\,mol\ Ba(OH)_2}{2\,mol\ HCl} = 0.001345\,mol\ Ba(OH)_2$

$[Ba(OH)_2] = \frac{0.001345\,mol\ Ba(OH)_2}{0.0250\,L\ Ba(OH)_2} = \boxed{0.0538\,M}$

20. 13.45 mL of 0.200 M $Sr(OH)_2$ is required to titrate 25.0 mL of a solution which is known to have HNO_3. Calculate the original $[HNO_3]$. Show all your steps. (3 marks)

mol $Sr(OH)_2$: $0.200\,M \times 0.01345\,L = 0.0026\,mol\ Sr(OH)_2$

(3) $Sr(OH)_2 + 2HNO_3 \rightarrow 2H_2O + Sr(NO_3)_2$

mol HNO_3: $0.00269\,mol\ Sr(OH)_2 \times \frac{2\,mol\ HNO_3}{1\,mol\ Sr(OH)_2} = 0.00538\,mol\ HNO_3$

$[HNO_3] = \frac{0.00538\,mol\ HNO_3}{0.0250\,L\ HNO_3} = \boxed{0.215\,M}$

(9)
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21. What volume of 0.100 M NaOH would be required to titrate 35.0 mL of a 0.231M solution of $H_2C_2O_4$. Show all your steps. (3 marks)

3

mol $H_2C_2O_4$ = 0.231 M × 0.0350 L = 0.008085 mol $H_2C_2O_4$

$H_2C_2O_4 + 2NaOH \rightarrow 2H_2O + Na_2C_2O_4$

mol/M/L

mol NaOH = 0.008085 mol $H_2C_2O_4$ × $\frac{2\ mol\ NaOH}{1\ mol\ H_2C_2O_4}$ = 0.01617 mol NaOH

L of NaOH = $\frac{0.01617\ mol}{0.100\ M}$ = 0.162 L or 162 mL

22. Consider the following 0.100 M solutions:

I. HF II. HBr III. H_2SO_4

0.001 mol 0.001 mol
HF + NaOH → H_2O + NaF
0.001 mol 0.001 mol
HBr + NaOH → H_2O + NaBr
0.001 mol 0.002 mol
H_2SO_4 + 2NaOH → $2H_2O$ + Na_2SO_4

1

The equivalence point is reached when 10.00 mL of 0.100 M NaOH has been added to 10.00 mL of solutions (1 mark) (#3 needs 0.002 mol NaOH)

mol = 0.100 M × 0.0100 L = 0.00100 mol

A. II only (B.) I and II only C. II and III only D. I, II and III

23. a) Write the *balanced formula equation* for the titration between sulphurous acid and potassium hydroxide. (1 mark)

1

$H_2SO_3 + 2KOH \rightarrow 2H_2O + K_2SO_3$

b) Write the *balanced net-ionic equation* for the titration between sulphurous acid and potassium hydroxide. (1 mark) (leave out spectator K^+)

1

$H_2SO_3 + 2OH^- \rightarrow 2H_2O + SO_3^{2-}$

24. Given the following data table:

1

Beaker	*Volume*	*Contents*
1	10.0 mL	0.1 M $Ba(OH)_2$
2	15.0 mL	0.2 M NH_3
3	20.0 mL	0.05 M KOH
4	50.0 mL	0.2 M NaOH

mol = 0.1 M × 0.010 L = 0.001 mol

0.001 mol → 0.002 mol

0.002 mol 0.003 mol
$Ba(OH)_2 + 2HCl \rightarrow 2H_2O + BaCl_2$
0.003 mol 0.003 mol
$NH_3 + HCl \rightarrow NH_4^+ + Cl^-$
0.001 mol 0.001 mol
KOH + HCl → H_2O + KCl
0.010 mol 0.01 mol
NaOH + HCl → H_2O + NaCl

a) 7/7

Which beaker would require the greatest volume of 0.1M HCl for complete neutralization? # 4 (NaOH) (1 mark)

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b) What volume of 0.1M HCl would be needed for the neutralization in (a)? (2 marks)

2

mol NaOH = 0.2M × 0.0500 L = 0.010mol NaOH

$NaOH + HCl \rightarrow H_2O + NaCl$

mol HCl = 0.01 mol NaOH × 1 mol HCl / 1 mol NaOH = 0.01 mol HCl

$L_{(HCl)} = \frac{mol}{M} = \frac{0.01\ mol}{0.1M} = 0.1\ L = 100\ mL$

Answer 100 mL

1

c) Which beaker would require the least volume of 0.1M HCl for complete neutralization? #3 (KOH) (1 mark)

d) What volume of 0.1M HCl would be needed for the neutralization in (c)? (2 marks)

2

mol KOH = 0.05M × 0.0200 L = 0.001 mol KOH

$KOH + HCl \rightarrow H_2O + KCl$

mol HCl = 0.001 mol KOH × 1 mol HCl / 1 mol KOH = 0.001 mol HCl

$L_{(HCl)} = \frac{mol}{M} = \frac{0.001\ mol}{0.1M} = 0.010\ L = 10\ mL$

Answer 10 mL

25. Calculate the mass of NaOH which is required to neutralize 15.00 mL of 0.350 M H_2SO_4? (3 marks)

3

mol H_2SO_4 = 0.350M × 0.01500L = 0.00525 mol H_2SO_4

$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$

mass NaOH

$0.00525\ mol\ H_2SO_4 \times \frac{2\ mol\ NaOH}{1\ mol\ H_2SO_4} \times \frac{40.0\ g\ NaOH}{1\ mol\ NaOH} = 0.420\ g$

(0.0105 mol)

Answer 0.420 grams

26. When a 0.1 M strong base titrates a 0.1 M weak monoprotic acid, it takes

1

(*less/more/the same*) the same volume of the base as it would to titrate a 0.1 M strong monoprotic acid. (1 mark)

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