

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

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Name KEY

Date Due \_\_\_\_\_

Correct &amp; 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)

a) $\text{ClO}_2$ ..... <u>A</u>	f) $\text{CO}_2$ ..... <u>A</u>
b) $\text{SrO}$ ..... <u>B</u>	g) $\text{Cs}_2\text{O}$ ..... <u>B</u>
c) $\text{Cr}_2\text{O}_3$ ..... <u>B</u>	h) $\text{BaO}$ ..... <u>B</u>
d) $\text{SeO}_2$ ..... <u>A</u>	i) $\text{SO}_3$ ..... <u>A</u>
e) $\text{NO}_2$ ..... <u>A</u>	j) $\text{Ag}_2\text{O}$ ..... <u>B</u>

2. a) Define a **basic anhydride** (1 mark) - an oxygen containing compound

① which reacts with water to form a basic solution ( $\text{OH}^-$ ).

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

③  $\text{BaO}$        $\text{Na}_2\text{O}$        $\text{ZnO}$  etc.

3. a) Define an **acidic anhydride** (1 mark) - an oxygen containing compound

① which reacts with water to form an acidic solution ( $\text{H}_3\text{O}^+$ )

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

③  $\text{SO}_2$        $\text{Cl}_2\text{O}$        $\text{CO}_2$  etc.

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



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

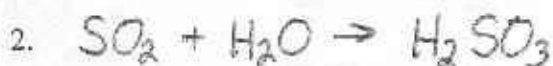
5. Normal (unpolluted) rain water usually has a pH of about 5.6. This is

② less than 7 due to CO<sub>2</sub> gas dissolving in the air. (2 marks)

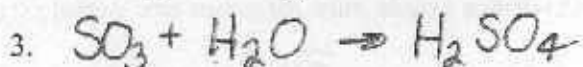
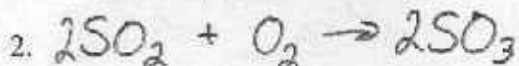
- ① 6. "Acid rain" could be defined as rain having a pH below 5.6. (1 mark)

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

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

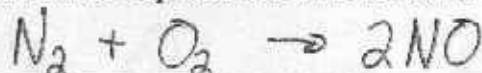


9. Give three formula equations which show how sulphuric acid can be produced starting with sulphur. (3 marks)



- 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 its elements. (1 mark)



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12. Give the balanced equation for the formation of  $\text{NO}_2$  from its elements. (1 mark)

1  $\text{N}_2 + 2\text{O}_2 \rightarrow 2\text{NO}_2$

13. Give the balanced equation for the formation of nitrous and nitric acid from  $\text{NO}_2$  dissolving in rain water. (1 mark)

1  $2\text{NO}_2 + \text{H}_2\text{O} \rightarrow \text{HNO}_2 + \text{HNO}_3$

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)  $\text{CaCO}_3$ ,  $\text{MgCO}_3$

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

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1. aquatic life affected
2. forests weakened
3. minerals (eg.  $\text{Al}^{3+}$ ) 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)

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1. International agreements to limit sulphur in fuels and  $\text{NO}_x$  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)

$$\text{mol NaOH} = 0.200 \text{ M} \times 0.01345 \text{ L} = \underline{0.00269 \text{ mol NaOH}}$$



$$\text{mol HCl} = 0.00269 \text{ mol NaOH} \times \frac{1 \text{ mol HCl}}{1 \text{ mol NaOH}} = \underline{0.00269 \text{ mol HCl}}$$

$$[\text{HCl}] = \frac{0.00269 \text{ mol HCl}}{0.0250 \text{ L HCl}} = \underline{0.108 \text{ M}}$$

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)<sub>2</sub>. Calculate the original [Ba(OH)<sub>2</sub>]. Show all your steps. (3 marks)

$$\text{mol HCl} = 0.200 \text{ M} \times 0.01345 \text{ L} = \underline{0.00269 \text{ mol HCl}}$$



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

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

20. 13.45 mL of 0.200 M Sr(OH)<sub>2</sub> is required to titrate 25.0 mL of a solution which is known to have HNO<sub>3</sub>. Calculate the original [HNO<sub>3</sub>]. Show all your steps. (3 marks)

$$\text{mol Sr(OH)}_2 = 0.200 \text{ M} \times 0.01345 \text{ L} = \underline{0.00269 \text{ mol Sr(OH)}_2}$$



$$\text{mol HNO}_3 = 0.00269 \text{ mol Sr(OH)}_2 \times \frac{2 \text{ mol HNO}_3}{1 \text{ mol Sr(OH)}_2} = \underline{0.00538 \text{ mol HNO}_3}$$

$$[\text{HNO}_3] = \frac{0.00538 \text{ mol HNO}_3}{0.0250 \text{ L HNO}_3} = \underline{0.215 \text{ M}}$$

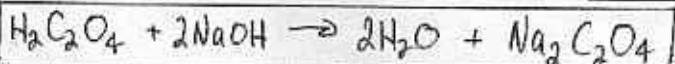
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21. What volume of 0.100 M NaOH would be required to titrate 35.0 mL of a 0.231 M solution of  $\text{H}_2\text{C}_2\text{O}_4$ . Show all your steps. (3 marks)

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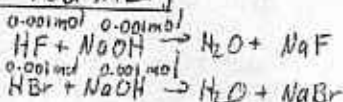
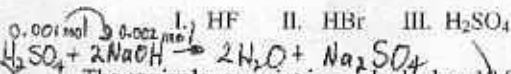
$$\text{mol H}_2\text{C}_2\text{O}_4 = 0.231 \text{ M} \times 0.0350 \text{ L} = 0.008085 \text{ mol H}_2\text{C}_2\text{O}_4$$



mol NaOH =  $0.008085 \text{ mol H}_2\text{C}_2\text{O}_4 \times \frac{2 \text{ mol NaOH}}{1 \text{ mol H}_2\text{C}_2\text{O}_4} = 0.01617 \text{ mol NaOH}$

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

22. Consider the following 0.100 M solutions:



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)

mol =  $0.100 \text{ M} \times 0.0100 \text{ L} = 0.00100 \text{ mol}$

- 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)



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



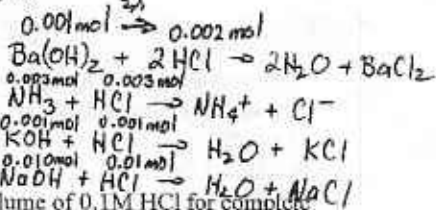
24. Given the following data table:

Beaker Volume

Contents

1	10.0 mL	0.1 M $\text{Ba}(\text{OH})_2$
2	15.0 mL	0.2 M $\text{NH}_3$
3	20.0 mL	0.05 M KOH
4	50.0 mL	0.2 M NaOH

mol =  $0.1 \text{ M} \times 0.010 \text{ L} = 0.001 \text{ mol}$



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

(NaOH)

KEY

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

$$\text{mol NaOH} = 0.2M \times 0.0500L = 0.010\text{mol NaOH}$$



$$\text{mol HCl} = 0.01\text{mol NaOH} \times \frac{1\text{mol HCl}}{1\text{mol NaOH}} = 0.01\text{mol HCl}$$

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

Answer 100 mL

- 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)

$$\text{mol KOH} = 0.05M \times 0.0200L = 0.001\text{mol KOH}$$



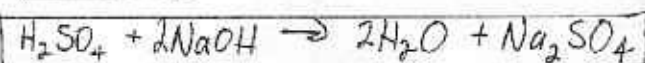
$$\text{mol HCl} = 0.001\text{mol KOH} \times \frac{1\text{mol HCl}}{1\text{mol KOH}} = 0.001\text{mol HCl}$$

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

Answer 10 mL

25. Calculate the mass of NaOH which is required to neutralize 15.00 mL of 0.350 M  $\text{H}_2\text{SO}_4$ ? (3 marks)

$$\text{mol H}_2\text{SO}_4 = 0.350M \times 0.01500L = 0.00525\text{mol H}_2\text{SO}_4$$



mass NaOH

$$0.00525\text{mol H}_2\text{SO}_4 \times \frac{2\text{mol NaOH}}{1\text{mol H}_2\text{SO}_4} \times \frac{40.0\text{g NaOH}}{1\text{mol NaOH}} = 0.420\text{g}$$

Answer 0.420 grams

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

(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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