1. Which gas sample contains the smallest number of molecules?

   A. 4 g of helium $\frac{4}{4} = 1$ mol

   B. 16 g of oxygen $\frac{16}{32} = 0.5$ mol

   C. 28 g of carbon monoxide $\frac{28}{12+16} = 1$ mol

   D. 28 g of nitrogen $\frac{28}{28} = 1$ mol

2. Which gas sample has the greatest mass?

   A. 5.0 moles of Cl_2 $5 \times 2 \times 35.5 = 355$

   B. 10.0 moles of O_2 $10 \times 32 = 320$

   C. 15.0 moles of N_2 $15 \times 28 = 420$

   D. 20.0 moles of H_2 $20 \times 2 = 40$

3. Which sample of magnesiumchloride, $MgCl_2$, contains the same number of moles as 69.6 g of potassium sulfate, K_2SO_4?

   $24 + 2 \times 35.5 = 95$

   $\frac{69.6}{39 \times 2 + 32 \times 4 \times 16} = \frac{69.6}{174} = 0.4$ mol

   A. 19.0 g

   B. 28.5 g

   C. 38.0 g $95 \times 0.4 = 38$ g

   D. 47.5 g

4. The compound magnesium nitrate has the formula $Mg(NO_3)_2$.

   What is the relative formula mass of magnesium nitrate?

   $24 + (14 + 3 \times 16) \times 2 = 148$

   A. 86

   B. 134

   C. 148

   D. 172

CORRECTION

5. The relative formula mass, M_r, of calcium carbonate, $CaCO_3$, is 100. What is the mass of carbon present in 100 g of calcium carbonate?

A. 12 g

B. 36 g

C. 40 g

D. 60 g

6. Four fertilisers are each supplied in 100 kg bags.

Which fertiliser supplies the greatest mass of nitrogen per 100 kg bag?

A. ammonium nitrate, NH_4NO_3 $\frac{2\times14}{14+4+14+3\times16} = \frac{28}{80} = 35\%$

B. ammonium phosphate, $(NH_4)_3PO_4$ $\frac{3\times14}{(18\times3+31)+4\times16} = \frac{42}{149} = 28.2\%$

C. ammonium sulfate, $(NH_4)_2SO_4$ $\frac{2\times14}{18\times2+32+4\times16} = \frac{28}{132} = 21.2\%$

D. urea, $CO(NH_2)_2$ $\frac{2\times14}{12+16+18\times2} = \frac{28}{64} = 43.8\%$

7. A sample of an iron oxide contains 50.4 g of iron and 21.6 g of oxygen.

What is the empirical formula of the iron oxide?

A. FeO

B. FeO_3

C. Fe_2O_3

D. Fe_3O_2

Fe : O

$\frac{50.4}{56} : \frac{21.6}{16}$

0.9 : 1.35

1 : 1.5

2 : 3

CORRECTION

8. An oxide of nitrogen has the following composition by mass: N, 30.4%; O, 69.6%. It has a relative molecular mass of 92.

What is the molecular formula of the oxide of nitrogen?

A. NO

B. NO_2

C. NO_4

D. N_2O_4

$\frac{30.4}{14} : \frac{69.6}{16}$

$= 2.17 : 4.37$

$= 1 : 2$

NO_2 $14+2\times16=46$

$\frac{92}{46}=2$

N_2O_4

9. Propane burns in oxygen.

$$C_3H_8 + x\,O_2 \rightarrow 3CO_2 + y\,H_2O$$

4

Which values of *x* and *y* balance the equation? 6+4=10 ÷2=5

	x	*y*
A	5 √	4 √
B	7	4 √
C	10	8
D	13	8

10. The equation for the reaction between magnesium and dilute sulfuric acid is shown.

The M_r of MgSO4 is 120.

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

Which mass of magnesium sulfate is formed when 12 g of magnesium completely reacts with dilute sulfuric acid?

$\frac{12}{24} \times 120$

A. 5 g

B. 10 g

C. 60 g

D. 120 g

CORRECTION

11. Phosphorus reacts with oxygen to form phosphorus(III) oxide as shown.

$$4P(s) + 3O_2(g) \rightarrow 2P_2O_3(s)$$

Which mass of phosphorus(III) oxide is produced from 6.2 g of phosphorus?

$\frac{6.2}{31} \times \frac{1}{2} \times (31\times2+16\times3) = 11$

A. 1.1 g

B. 5.5 g

C. 11.0 g

D. 22.0 g

12. Magnesium burns in oxygen to form magnesium oxide. The equation for the reaction is shown.

$$2Mg + O_2 \rightarrow 2MgO$$

Which mass of magnesium oxide is formed when 48 g of magnesium is burned?

$\frac{48}{24} \times (24+16) = 80$

A. 20 g

B. 40 g

C. 80 g

D. 160 g

13. The thermal decomposition of 12.5g of limestone (impure calcium carbonate) produces 5 g of calcium oxide.

Which mass of calcium oxide is produced by the thermal decomposition of 30 g of limestone?

$\frac{30}{12.5} \times 5 = 12g$

A. 6g

B. 12g

C. 15g

D. 24g

CORRECTION

14. Magnesium carbonate decomposes on heating to form magnesium oxide and carbon dioxide as shown.

$$MgCO_3 \rightarrow MgO + CO_2$$

How much magnesium carbonate is needed to make 5.0 g of magnesium oxide?

$\frac{5.0}{24+16} \times (24+12+3\times16)$

A. 3.5 g

B. 4.0 g

C. 6.5 g

D. 10.5 g

15. Calcium carbonate, $CaCO_3$, reacts with dilute hydrochloric acid to produce carbon dioxide. The equation for the reaction is shown. The relative formula mass of calcium carbonate is 100.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

10 g of calcium carbonate is reacted with an excess of dilute hydrochloric acid.

Which mass of carbon dioxide is produced?

$\frac{10}{100} \times 44$

A. 2.2 g

B. 2.8 g

C. 4.4 g

D. 44 g

CORRECTION

16. Calcium carbonate is heated. Calcium oxide and carbon dioxide gas are formed.

The equation for the reaction is shown.

$$CaCO_3 \rightarrow CaO + CO_2$$

225 kg of calcium carbonate is heated until there is no further change in mass. The yield of calcium oxide is 85 kg.

What is the percentage yield?

$\frac{225}{100} \times (40+16) = 126g$

$\frac{85}{126} \times 100\% = 67.5\%$

A. 37.8%

B. 47.2%

C. 67.5%

D. 85.0%

17. 90 g of glucose is dissolved in water. The glucose solution is fermented.

$$C_6H_{12}O_6 \rightarrow 2CO_2 + 2C_2H_5OH$$

glucose,Mr = 180 ethanol, Mr = 46

After the fermentation finishes, 6.8 g of ethanol is obtained from the solution.

What is the percentage yield of ethanol?

$\frac{90}{180} \times 2 \times 46 = 46g$

$\frac{6.8}{46} \times 100 = 14.8$

A. 7.4

B. 7.6

C. 14.8

D. 29.6

CORRECTION

18. A student mixed together 25.0 cm^3 of 1.00 mol/dm^3 hydrochloric acid and 25.0 g of calcium carbonate.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

What is the maximum volume of carbon dioxide gas that could be collected at room temperature and pressure?

A. 300 dm^3

B. 6.00 dm^3

C. 0.600 dm^3

D. 0.300 dm^3

$n(HCl) = 0.025 \times 1 = 0.025$ mol → limiting

$n(CaCO_3) = \frac{25.0}{100} = 0.25$ mol

$n(CO_2) = \frac{1}{2} n(HCl) = 0.0125$ mol

$V = 0.0125 \times 24 = 0.3$ dm^3

19. The equation for the combustion of ethane is shown.

$$2C_2H_6 + 7O_2 \rightarrow 4CO_2 + 6H_2O$$

Which volume of carbon dioxide, at room temperature and pressure, is formed when 0.5 moles of ethane burn?

A. 48 dm^3

B. 24 dm^3

C. 12 dm^3

D. 6 dm^3

$\frac{0.5}{2} \times 4 \times 24 = 24$

20. The equation for the reaction between potassium carbonate and nitric acid is shown.

$$K_2CO_3 + 2HNO_3 \rightarrow 2KNO_3 + H_2O + CO_2$$

Which volume of carbon dioxide is produced from 69 g of potassium carbonate?

A. 6 dm^3

B. 12 dm^3

C. 24 dm^3

D. 48 dm^3

$\frac{69}{39 \times 2 + 16 + 3 \times 16} = \frac{69}{142} = 0.486$

$0.486 \times 24 = 11.7$ dm^3

CORRECTION

21. The equation for the reaction between calcium carbonate and dilute nitric acid is shown.

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

25 g of calcium carbonate is reacted with an excess of dilute nitric acid.

Which mass of calcium nitrate and which volume of carbon dioxide is produced at room temperature and pressure?

	mass of calcium nitrate / g	volume of carbon dioxide / dm^3
A	29	6
B	29	12
C	41	6
D	41	12

22. An experiment was done to determine the formula of a hydrocarbon, C_xH_y.

10 cm^3 of the gaseous hydrocarbon, C_xH_y, was burned in an excess of oxygen to form 20 cm^3 of carbon dioxide and 30 cm^3 of water vapour.

What is C_xH_y?

A. CH_4

B. C_2H_4

C. C_2H_6

D. C_3H_8

23. Which gas sample contains the most molecules?

A. 24 dm^3 of carbon dioxide, CO_2

B. 4 g of hydrogen, H_2

C. 36 dm^3 of hydrogen chloride, HCl

D. 14 g of nitrogen, N_2

CORRECTION

24. A tablet contains 0.080 g of ascorbic acid (M_r = 176).

What is the concentration of ascorbic acid when one tablet is dissolved in 200 cm³ of water?

$\frac{0.080/176}{0.2} = 2.27 \times 10^{-3}$

A. 9.1×10^{-5} mol/dm^3

B. 4.5×10^{-4} mol/dm^3

C. 9.1×10^{-2} mol/dm^3

(D.) 2.3×10^{-3} mol/dm^3

25. What is the concentration of a solution that contains 25.0 g NaOH in 500 cm³ of water?

$\frac{25.0/40}{0.5} = 1.25$

A. 0.125 mol/dm^3

B. 0.800 mol/dm^3

(C.) 1.25 mol/dm^3

D. 3.20 mol/dm^3

26. 25.0 cm³ of 0.100 mol/dm³ aqueous sodium hydroxide is neutralised by 24.6 cm³ of dilute sulfuric acid.

What is the concentration of the dilute sulfuric acid?

(A.) 0.0508 mol/dm^3

B. 0.0984 mol/dm^3

C. 0.102 mol/dm^3

D. 0.203 mol/dm^3

$2NaOH + H_2SO_4$

$n(NaOH) = 0.025 \times 0.1 = 0.0025$ mol

$n(H_2SO_4) = \frac{1}{2} n(NaOH) = 0.00125$ mol

$[H_2SO_4] = \frac{0.00125}{0.0246} = 0.0508$

CORRECTION

12+3+12+2×16+1 = 60

27. A solution of ethanoic acid, CH_3COOH, has a concentration of 2 mol/dm^3.

Which statement about this solution is correct?

A. 20 g of ethanoic acid is dissolved in 10 cm^3 of water. X

B. 30 g of ethanoic acid is dissolved in 250 cm^3 of water.

C. 60 g of ethanoic acid is dissolved in 1 dm^3 of water. X

D. 120 g of ethanoic acid is dissolved in 2 dm^3 of water. X

28. A solution of sodium carbonate, Na_2CO_3, has a concentration of 0.03 mol/dm^3.

Which mass of sodium carbonate is dissolved in 1 dm^3 of this solution?

A. 1.06 g

23×2+12+16×3 = 106

B. 3.18 g

×0.03 = 3.18g

C. 10.60 g

D. 31.80 g

$\frac{4}{40}$ = 0.1 mol

29. 4.00 g of solid sodium hydroxide is added to water to make a solution with a concentration of 0.200 mol/dm^3.

$\frac{0.1}{0.2}$ = 0.5 dm^3

What is the volume of water used?

A. 0.5 cm^3

B. 20 cm^3

C. 500 cm^3

D. 2000 cm^3

CORRECTION

30. The concentration of a hydrochloric acid solution is 0.5 mol/dm^3.

How many moles of hydrochloric acid are present in 25 cm^3 of this solution?

A. 0.0125

B. 0.0200

C. 12.5

D. 20.0

$0.5 \times 25 \times 10^{-3} = 0.0125$ mol

31. Calcium carbonate reacts with dilute hydrochloric acid. The equation for the reaction is shown.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$$

1.00 g of calcium carbonate is added to 50.0 cm^3 of 0.0500 mol/dm^3 hydrochloric acid.

Which volume of carbon dioxide is made in this reaction?

A. 30 cm^3

B. 60 cm^3

C. 120 cm^3

D. 240 cm^3

$n(CaCO_3) = \frac{1}{100} = 0.01$ mol

$n(HCl) = 0.0500 \times 50 \times 10^{-3} = 0.0025$ mol → limiting

$n(CO_2) = \frac{1}{2} n(HCl) = 0.00125$ mol

$V = 24 \times 0.00125 = 0.03 = 30$ cm^3

CORRECTION

32. Calcium carbonate reacts with dilute hydrochloric acid according to the equation shown.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

10 g of calcium carbonate is reacted with 100 cm^3 of 1 mol/dm^3 hydrochloric acid. The following statements are made.

1 1.2 dm^3 of carbon dioxide is formed.

2 5.6 g of calcium chloride is formed.

3 4.8 g of carbon dioxide is formed.

4 No calcium carbonate is left when the reaction is completed.

Which statements about the reaction are correct?

A. 1 and 2

B. 1 and 4

C. 2 and 3

D. 3 and 4

CORRECTION

33. A 0.095 g sample of gaseous element Y occupies 60.0 cm³ at room temperature and pressure.

(a) Determine the number of moles of element Y in 60.0 cm³.

$\frac{60.0 \times 10^{-3}}{24} = 0.0025$ mol

(b) Calculate the relative molecular mass of element Y and hence suggest the identity of element Y.

$M = \frac{0.095}{0.0025} = 38$

$38 \div 2 = 19$

F

(c) A 1.68 g sample of phosphorus was burned and formed 3.87 g of an oxide of phosphorus.

Calculate the empirical formula of this oxide of phosphorus.

$n(P) : n(O) = \frac{1.68}{31} : \frac{3.87-1.68}{16} = 0.0542 : 0.137 = 1 : 2.5$

$= 2 : 5$

P_2O_5

(d) Another oxide of phosphorus has the empirical formula P_2O_3.

One molecule of this oxide of phosphorus contains four atoms of phosphorus.

Calculate the mass of one mole of this oxide of phosphorus.

P_4O_{10}

$4 \times 31 + 10 \times 16 = 284$

CORRECTION

34. Many organic compounds, such as alcohols, carboxylic acids and esters, contain the elements carbon, hydrogen and oxygen only.

(a) Compound R has the following composition by mass: C, 60.00%; H, 13.33%; O, 26.67%.

Calculate the empirical formula of compound R.

$\frac{60}{12} : \frac{13.33}{1} : \frac{26.67}{16} = 5 : 13.33 : 1.67$

$= 3 : 8 : 1$

C_3H_8O

$2 \times 12 + 4 + 16 = 44$

(b) Compound S has the empirical formula C_2H_4O and a relative molecular mass of 88.

Calculate the molecular formula of compound S.

$C_4H_8O_2$

CORRECTION

35. Forsterite is another rock which contains a magnesium compound.

A sample of forsterite has the following composition by mass: Mg, 2.73 g; Si, 1.58 g; O, 3.60 g. Calculate the empirical formula of forsterite.

$$\frac{2.73}{24} : \frac{1.58}{28} : \frac{3.60}{16}$$

$$= 0.114 : 0.0564 : 0.225$$

$$= 2 : 1 : 4$$

Mg_2SiO_4

36. Nickel(II) iodide crystals are hydrated. A sample of hydrated nickel(II) iodide crystals has the following composition by mass: Ni, 14.01%; I, 60.33%; H, 2.85%; O, 22.81%. Calculate the empirical formula of the hydrated nickel(II) iodide crystals.

$$\frac{14.01}{59} : \frac{60.33}{127} : \frac{2.85}{1} : \frac{22.81}{16}$$

$$= 0.237 : 0.475 : 2.85 : 1.43$$

$$= 1 : 2 : 12 : 6$$

$NiI_2 \cdot 6H_2O$

CORRECTION

37. Sulfur dioxide reacts with aqueous sodium sulfite to produce a compound with the following composition by mass: 29.1% Na, 40.5% S and 30.4% O.

Calculate the empirical formula of this compound.

$\frac{29.1}{23} : \frac{40.5}{32} : \frac{30.4}{16}$

$= 1.27 : 1.27 : 1.9$

$= 1 : 1 : 1.5 = 2 : 2 : 3$

$Na_2S_2O_3$

38. Phosphorus forms another compound with hydrogen with the following composition by mass: P, 93.94%; H, 6.06%.

(a) Calculate the empirical formula of the compound.

$\frac{93.94}{31} : \frac{6.06}{1}$

$= 3.03 : 6.06$

$= 1 : 2$

PH_2

↓

33

(b) The compound has a relative molecular mass of 66.

Deduce the molecular formula of the compound.

P_2H_4

CORRECTION

39. Tin is a metallic element in Group IV. Its main ore is cassiterite which is an impure form of tin(IV) oxide, SnO_2.

Tin also occurs in stannite, Cu_2FeSnS_4.

(a) Calculate the relative formula mass, M_r, of Cu_2FeSnS_4.

$64 \times 2 + 56 + 119 + 32 \times 4 = 431$

(b) The M_r of SnO2 is 151.

Calculate the percentage of tin by mass in SnO_2.

$\frac{119}{151} \times 100 = 78.8\%$

CORRECTION

(c) The percentage of tin by mass in Cu_2FeSnS_4 is 27.6%.

Use this information and your answer to (b) to suggest whether it would be better to extract tin from SnO_2 or Cu_2FeSnS_4.

Explain your answer.

SnO_2

it has greater Sn content.

40. Iron(II) sulfate decomposes when heated strongly.

$$2FeSO_4(s) \rightarrow Fe_2O_3(s) + SO_2(g) + SO_3(g)$$

15.20 g of $FeSO_4$(s) was heated and formed 4.80 g of Fe_2O_3(s).

[M_r, $FeSO_4$ = 152; M_r, Fe_2O_3 = 160]

Calculate the percentage yield for this reaction.

$$\frac{1}{2} \times \frac{15.20}{152} \times 160 = 8$$

$$\frac{4.80}{8} \times 100 = 60\%$$

CORRECTION

41. A teacher heated 18.8 g of copper(II) nitrate.

(a) Complete the chemical equation for the reaction.

$$2Cu(NO_3)_2 \rightarrow O_2 + \text{...2...}NO_2 + \text{....2CuO.....}$$

(b) Calculate the number of moles of copper(II) nitrate present in the 18.8 g.

$$\frac{18.8}{64+(14+3\times16)\times2} = 0.1 \text{ mol}$$

(c) Calculate the maximum number of moles of oxygen that can be made by heating 18.8 g of copper(II) nitrate.

0.05 mol

(d) Calculate the maximum volume of oxygen at room temperature and pressure, in cm^3, that can be made by heating 18.8 g of copper(II) nitrate.

$0.05 \times 24 \times 10^3 = 1200\ cm^3$

CORRECTION

42. Calcium chlorate(V), $Ca(ClO_3)_2$, is made by reacting calcium hydroxide with chlorine gas.

$$6Ca(OH)_2 + 6Cl_2 \rightarrow Ca(ClO_3)_2 + 5CaCl_2 + 6H_2O$$

8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas are mixed together.

(a) How many moles is 8.88 g of calcium hydroxide?

$$\frac{8.88}{40+1+16} = 0.156\text{ mol}$$

(b) How many moles of chlorine gas is 7200 cm^3?

$$\frac{7200 \times 10^{-3}}{24} = 0.3\text{ mol}$$

(c) What is the maximum number of moles of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 cm^3 of chlorine gas?

$$n(Ca(ClO_3)_2) = \frac{1}{6} n(Ca(OH)_2) = 0.026\text{ mol}$$

CORRECTION

(d) What is the maximum mass of calcium chlorate(V) that can be made from 8.88 g of calcium hydroxide and 7200 cm³ of chlorine gas?

$M(Ca(ClO_3)_2) = 40 + (35.5 + 3 \times 16) \times 2 = 207$

$m = 207 \times 0.026 = 5.382\,g$

The experiment is repeated using different amounts of calcium hydroxide and chlorine gas.

The maximum mass of calcium chlorate(V) that can be made in the experiment is 4.84 g.

(e) The actual mass of calcium chlorate(V) made in the experiment is 3.63 g.

Calculate the percentage yield.

$\frac{3.63}{4.84} \times 100 = 75\%$

CORRECTION

43. Nitrates such as ammonium nitrate are used as fertilisers.

The final stage in the production of ammonium nitrate is shown in the equation.

$$Ca(NO_3)_2 + 2NH_3 + CO_2 + H_2O \rightarrow 2NH_4NO_3 + CaCO_3$$

Calculate the maximum mass of ammonium nitrate that can be produced from 820 g of calcium nitrate, $Ca(NO_3)_2$, using the following steps.

The relative formula mass, M_r, of calcium nitrate, $Ca(NO_3)_2$, = 164.

(a) Calculate the number of moles of $Ca(NO_3)_2$ in 820 g.

$\frac{820}{164} = 5$ mol

(b) Deduce the number of moles of NH_4NO_3 produced.

10 mol

(c) Calculate the M_r of NH_4NO_3.

$14 + 4 + 14 + 3 \times 16 = 80$

(d) Calculate the maximum mass of ammonium nitrate produced.

$10 \times 80 = 800$ g

CORRECTION

44. Some car airbags contain sodium azide.

When a car airbag is used the sodium azide, NaN_3, decomposes. The products are nitrogen and sodium.

The equation for the decomposition of sodium azide is shown.

$$2NaN_3(s) \rightarrow 2Na(l) + 3N_2(g)$$

Calculate the mass, in g, of sodium azide needed to produce 144 dm^3 of nitrogen using the following steps.

(a) Calculate the number of moles in 144 dm^3 of N_2 measured at room temperature and pressure.

$\frac{144}{24} = 6$ mol

(b) Determine the number of moles of NaN3 needed to produce this number of moles of N_2.

$6 \times \frac{2}{3} = 4$ mol

(c) Calculate the relative formula mass, M_r, of NaN_3.

$23 + 3 \times 14 = 65$

(d) Calculate the mass of NaN_3 needed to produce 144 dm^3 of N_2.

$4 \times 65 = 260$g

CORRECTION

45. Ammonia reacts with chlorine. The chemical equation is shown.

$$2NH_3(g) + 3Cl_2(g) \rightarrow N_2(g) + 6HCl(g)$$

Calculate the volume of chlorine, measured at room temperature and pressure, needed to react completely with 0.68g of ammonia.

M(NH3) = 17

$\frac{0.68}{17} = 0.04$ mol

$\frac{0.04}{2} \times 3 = 0.06$ mol

$0.06 \times 24 = 1.44$ dm^3

46. Ammonia reacts with oxygen as shown.

$$4NH_3(g) + 5O_2(g) \rightarrow 4NO(g) + 6H_2O(g)$$

Calculate the volume of oxygen at room temperature and pressure, in dm^3, that reacts with 4.80 dm^3 of ammonia.

$\frac{4.80}{4} \times 5 = 6.00$ dm^3

CORRECTION

47. Calculate the volume of chlorine gas, $Cl_2(g)$, at room temperature and pressure, that reacts completely with 400 g of $TiO_2(s)$ using the following steps.

$$TiO_2(s) + 2Cl_2(g) + 2C(s) \rightarrow TiCl_4(g) + 2CO(g)$$

(a) Calculate the relative formula mass, M_r, of TiO_2.

48+2x16=80

(b) Calculate the number of moles in 400 g of TiO_2.

$\frac{400}{80}$ = 5 mol

(c) Determine the number of moles of Cl_2 that react with 400 g of TiO_2.

$n(Cl_2)$ = 10 mol

(d) Calculate the volume of Cl_2 that reacts with 400 g of TiO_2.

10 x 24 = 240 dm^3

CORRECTION

48. Copper(II) sulfate crystals, $CuSO_4{\cdot}5H_2O$, are hydrated.

Copper(II) sulfate crystals are made by reacting copper(II) carbonate with dilute sulfuric acid. The equation for the overall process is shown.

$$CuCO_3 + H_2SO_4 + 4H_2O \rightarrow CuSO_4{\cdot}5H_2O + CO_2$$

step 1 Powdered solid copper(II) carbonate is added to 50.0 cm^3 of 0.05 mol/dm^3 sulfuric acid until the copper(II) carbonate is in excess.

step 2 The excess of copper(II) carbonate is separated from the aqueous copper(II) sulfate.

step 3 The aqueous copper(II) sulfate is heated until the solution is saturated.

step 4 The solution is allowed to cool and crystallise.

step 5 The crystals are removed and dried.

(a) Calculate the maximum mass of the copper(II) sulfate crystals, $CuSO_4{\cdot}5H_2O$, that can form using the following steps.

- Calculate the number of moles of H_2SO_4 in 50.0 cm^3 of 0.05 mol/dm^3 H_2SO_4.

$50.0 \times 10^{-3} \times 0.05 = 0.0025$ mol

- Determine the number of moles of $CuSO_4{\cdot}5H_2O$ that can form.

0.0025 mol

CORRECTION

The M_r of $CuSO_4{\cdot}5H_2O$ is 250.

- Calculate the maximum mass of $CuSO_4{\cdot}5H_2O$ that can form.

0.0025 × 250 = 0.625 g

(b) Steps 1–5 were done correctly but the mass of crystals obtained was less than the maximum mass.

Explain why.

Some crystals lost during transfer.

or some copper (II) sulfate remains in solution

(c) State two observations that would indicate that the copper(II) carbonate is in excess in step 1.

Solid (powder, $CuCO_3$) stops dissolving.

no more bubbles

CORRECTION

49. Silver chloride can be made by reacting aqueous sodium chloride with aqueous silver nitrate. The other product of the reaction is sodium nitrate. The chemical equation for the reaction is shown.

$$NaCl(aq) + AgNO_3(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

A student attempted to make the maximum amount of sodium nitrate crystals. The process involved three steps.

step 1 The student added aqueous sodium chloride to aqueous silver nitrate and stirred. Neither reagent was in excess.

step 2 The student filtered the mixture. The student then washed the residue and added the washings to the filtrate.

step 3 The student obtained sodium nitrate crystals from the filtrate.

(a) Describe what the student observed in step 1.

white precipitate was formed

(b) Why was the residue washed in step 2?

to ensure all $NaNO_3$ are removed from precipitate and collect in filtrate.

(c) Give the names of the two processes which occurred in step 3.

evaporation and crystallisation

CORRECTION

(d) The student started with 20 cm3 of 0.20 mol/dm3 NaCl(aq).

- Determine the amount of NaCl(aq) used.

$20 \times 10^{-3} \times 0.20 = 0.0040$ mol

The yield of NaNO3 crystals was 90%.

- Calculate the mass of NaNO3 crystals made.

$23 + 14 + 3 \times 16 = 85$

$0.0040 \times 85 \times 90\% = 0.306g$

(e) Write a chemical equation for the action of heat on sodium nitrate crystals.

$2NaNO_3 \rightarrow 2NaNO_2 + O_2$

CORRECTION

50. Hydrochloric acid produces salts called chlorides.

Magnesium carbonate reacts with hydrochloric acid to produce magnesium chloride.

$$MgCO_3 + 2HCl \rightarrow MgCl_2 + H_2O + CO_2$$

A student used 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid in an experiment to produce magnesium chloride.

Calculate the mass, in g, of magnesium carbonate needed to react exactly with 50.00 cm^3 of 2.00 mol/dm^3 hydrochloric acid using the following steps.

(a) Calculate the number of moles of HCl present in 50.00 cm_3 of 2.00 mol/dm^3 HCl.

$50 \times 10^{-3} \times 2.00 = 0.1$ mol

(b) Determine the number of moles of $MgCO_3$ which would react with 50.00 cm^3 of 2.00 mol/dm^3 HCl.

0.05 mol

(c) Calculate the relative formula mass, M_r, of $MgCO_3$.

$24 + 12 + 3 \times 16 = 84$

(d) Calculate the mass of $MgCO_3$ needed to react exactly with 50.00 cm^3 of 2.00 mol/dm^3 HCl.

$84 \times 0.05 = 4.2$g

CORRECTION

51. Dilute sulfuric acid reacts with aqueous sodium hydrogencarbonate in a neutralisation reaction.

$$H_2SO_4(aq) + 2NaHCO_3(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) + 2CO_2(g)$$

In a titration, 0.200 mol/dm^3 aqueous sodium hydrogencarbonate was used to neutralise 20.0 cm^3 of dilute sulfuric acid of concentration 0.150 mol/dm^3.

(a) Calculate the number of moles of dilute sulfuric acid used in the titration.

$20.0 \times 10^{-3} \times 0.150 = 0.003$ mol

(b) Calculate the number of moles of sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

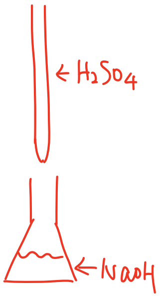
0.006 mol

(c) Calculate the volume, in cm3, of 0.200 mol/dm^3 aqueous sodium hydrogencarbonate needed to neutralise the dilute sulfuric acid.

$\frac{0.006}{0.200} \times 10^3 = 30 cm^3$

CORRECTION

52. In a titration, a student added 25.0 cm^3 of 0.200 mol/dm^3 aqueous sodium hydroxide to a conical flask. The student then added a few drops of methyl orange to the solution in the conical flask.



Dilute sulfuric acid was then added from a burette to the conical flask. The volume of dilute sulfuric acid needed to neutralise the aqueous sodium hydroxide was 20.0 cm^3.

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

(a) What was the colour of the methyl orange in the aqueous sodium hydroxide?

yellow

(b) Determine the concentration of the dilute sulfuric acid in g/dm^3.

- Calculate the number of moles of aqueous sodium hydroxide added to the conical flask.

  $n(NaOH) = 25.0 \times 10^{-3} \times 0.200 = 0.00500$ mol

- Calculate the number of moles of dilute sulfuric acid added from the burette.

  0.00250 mol

- Calculate the concentration of the dilute sulfuric acid in mol/dm^3.

  $\frac{0.00250}{0.020} = 0.125$ mol dm^{-3}

- Calculate the concentration of the dilute sulfuric acid in g/dm^3.

  $0.125 \times 98 = 12.25$ g dm^{-3}

CORRECTION

53. Dilute hydrochloric acid, HCl (aq), reacts with aqueous sodium carbonate, Na_2CO_3(aq).

The chemical equation for the reaction is shown.

$$2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$$

(a) A 25.0 cm^3 portion of Na_2CO_3(aq) was placed in a conical flask with a few drops of a suitable indicator. It was titrated against HCl(aq) of concentration 0.180 mol/dm^3.

20.0 cm^3 of HCl(aq) was required to reach the end-point.

Calculate the concentration of the Na_2CO_3(aq), in mol/dm^3, using the following steps.

- Calculate the number of moles of HCl used in the titration.

$0.180 \times 20.0 \times 10^{-3} = 0.0036$ mol

- Calculate the number of moles of Na_2CO_3 contained in the 25.0 cm^3 portion of Na_2CO_3(aq).

0.0018 mol

- Calculate the concentration of the Na_2CO_3(aq) in mol/dm^3.

$\frac{0.0018}{0.025} = 0.072$

CORRECTION

(b) In another experiment, the volume of carbon dioxide, CO_2, produced was 48.0 cm^3, measured at room temperature and pressure.

How many moles of CO_2 is this?

$$\frac{48 \times 10^{-3}}{24} = 2 \times 10^{-3} \text{ mol}$$

(c) A sample of concentrated hydrobromic acid, HBr(aq), was electrolysed using platinum electrodes.

The concentration of the hydrobromic acid was 8.89 mol/dm^3.

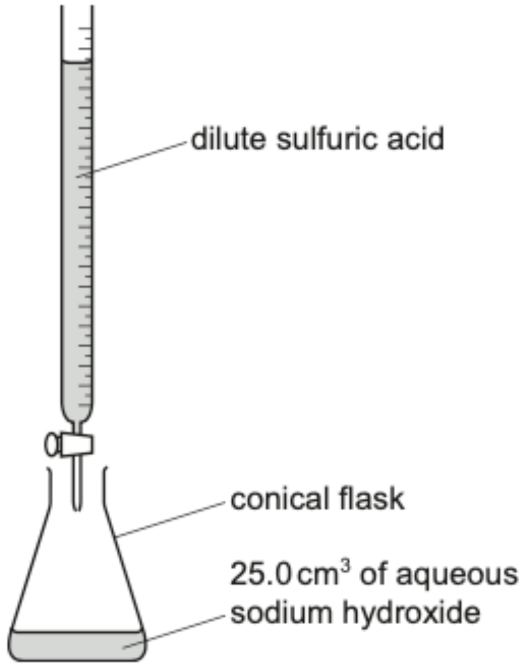
Calculate the concentration of the HBr(aq) in g/dm^3.

$$8.89 \times (1 + 80) = 7.2 \times 10^{2} \text{ g dm}^{-3}$$

mol dm^{-3} $\quad$ g mol^{-1}

CORRECTION

54. Dilute sulfuric acid and aqueous sodium hydroxide are used to make aqueous sodium sulfate, $Na_2SO_4(aq)$, or aqueous sodium hydrogen sulfate, $NaHSO_4(aq)$. The method includes use of the following apparatus.



25.0 cm^3 of aqueous sodium hydroxide of concentration 0.100 mol/dm^3 was neutralised by 25.0 cm^3 of dilute sulfuric acid of concentration 0.0500 mol/dm^3. The equation for the reaction is shown. This is reaction 1.

$$2NaOH(aq) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l) \qquad \text{reaction 1}$$

The same technique and the same solutions can be used to make aqueous sodium hydrogen sulfate. The equation for the reaction is shown. This is reaction 2.

$$NaOH(aq) + H_2SO_4(aq) \rightarrow NaHSO_4(aq) + H_2O(l) \qquad \text{reaction 2}$$

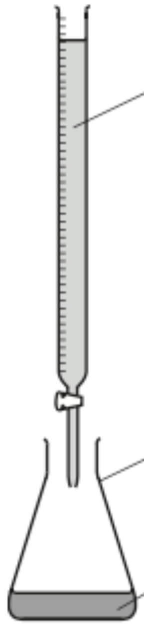
CORRECTION

Complete the table to calculate the volume of dilute sulfuric acid that reacts with 25.0 cm^3 of aqueous sodium hydroxide in reaction 2.

	volume of 0.0500 mol / dm^3 dilute sulfuric acid in cm^3	volume of 0.100 mol / dm^3 aqueous sodium hydroxide in cm^3
reaction 1	25.0	25.0
reaction 2	50.0	25.0

CORRECTION

55. Dilute sulfuric acid and aqueous potassium hydroxide can be used to make potassium sulfate crystals using a method that includes titration.



A student titrated 25.0 cm^3 of 0.0500 mol/dm^3 aqueous potassium hydroxide with dilute sulfuric acid in the presence of an indicator. The volume of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide was 20.0 cm^3.

The equation for the reaction is shown.

$$H_2SO_4 + 2KOH \rightarrow K_2SO_4 + 2H_2O$$

(a) Determine the concentration of the dilute sulfuric acid.

- Calculate the number of moles of aqueous potassium hydroxide used.

$25.0 \times 10^{-3} \times 0.0500 = 0.00125$ mol

CORRECTION

- Calculate the number of moles of dilute sulfuric acid needed to neutralise the aqueous potassium hydroxide.

$\frac{1}{2} \times 0.00125 = 0.000625$ mol

- Calculate the concentration, in mol/dm^3, of the dilute sulfuric acid.

$\frac{0.000625}{20 \times 10^{-3}} = 0.03125$ mol dm^{-3}

(b) After the titration has been completed, the conical flask contains an aqueous solution of potassium sulfate and some of the dissolved indicator.
Describe how to prepare a pure, dry sample of potassium sulfate crystals from new solutions of dilute sulfuric acid and aqueous potassium hydroxide of the same concentrations as used in the titration. Include a series of key steps in your answer.

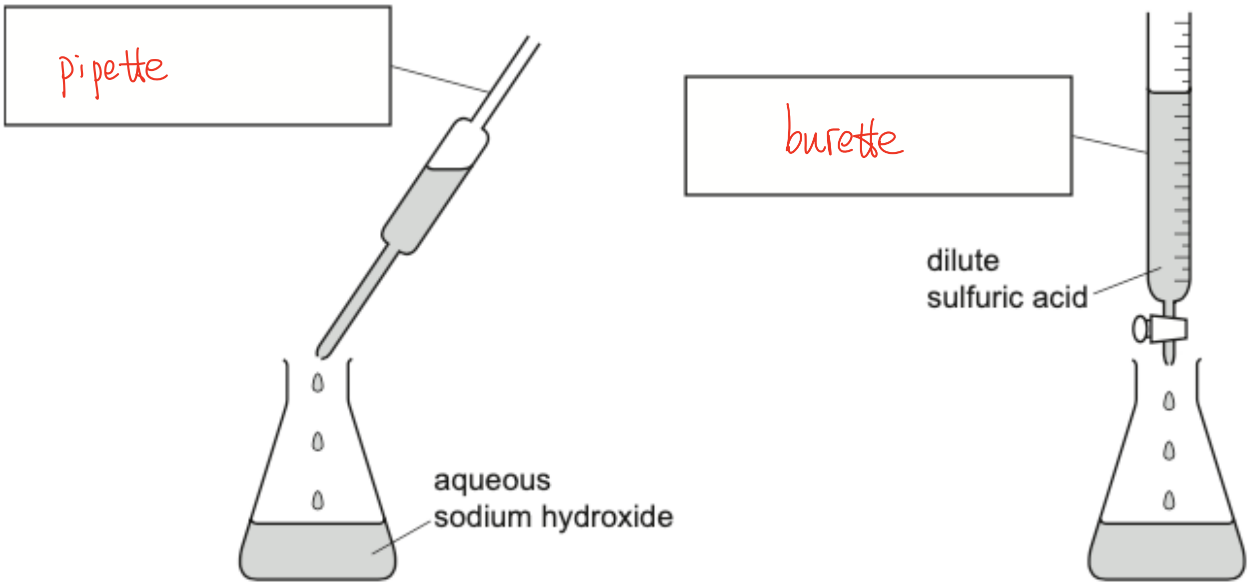
repeat without indicator using same volume.
evaporate
until most of water is gone
leave cool to crystallise
drying

CORRECTION

56. A student did a single titration to find the concentration of a solution of dilute sulfuric acid.

The student added 25.0cm3 of aqueous sodium hydroxide to a conical flask, followed by a few drops of indicator. Dilute sulfuric acid was then added to the aqueous sodium hydroxide until the solution was neutral.

The apparatus used is shown in the diagram.



(a) Complete the boxes to name the apparatus.

(b) Name a suitable indicator to use in the titration and give the colour change.

methyl orange: yellow to orange

CORRECTION

(c) After the titration, the student discarded the contents of the conical flask and rinsed the conical flask with distilled water.

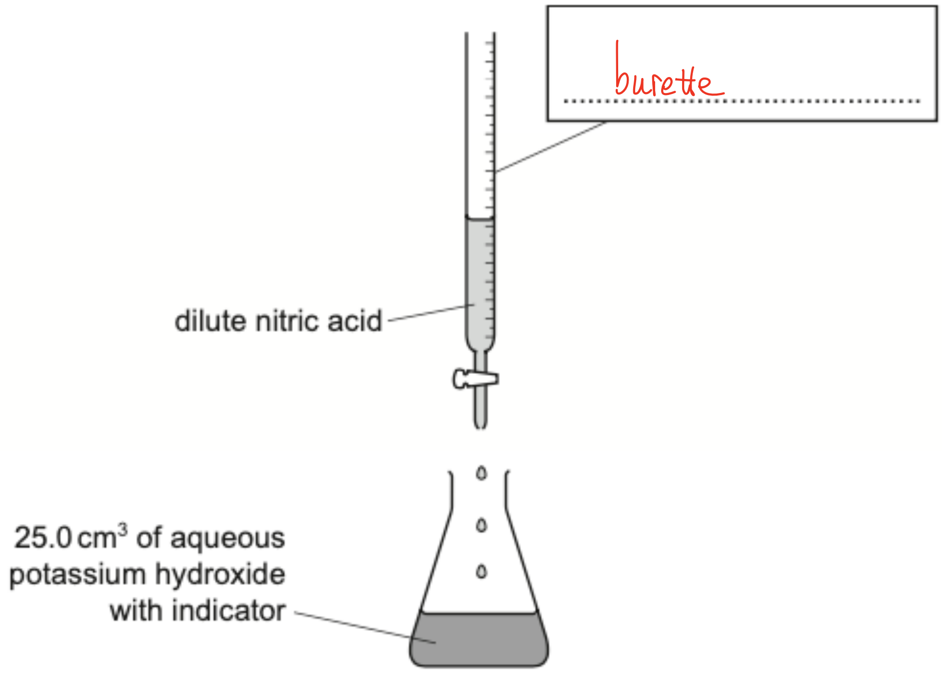
Suggest and explain what would be the effect, if any, on the titration values if the conical flask was not dried before repeating the titration.

same

moles of NaOH added still same

CORRECTION

57. The volume of dilute nitric acid that reacts with 25.0 cm^3 of aqueous potassium hydroxide can be found by titration using the apparatus shown.



(a) Complete the box to name the apparatus.

(b) Name a suitable indicator that could be used. methyl orange: yellow to orange

A student did the titration four times and recorded the following results.

titration number	volume of dilute nitric acid / cm^3
1	18.1
2	18.9
3	18.3
4	18.2

(c) (i) Which one of the results is anomalous?

18.9

CORRECTION

(ii) Suggest what might have caused this result to be anomalous.

overshoot end-point
more than 25 cm^3 of KOH in flask.

(iii) Use the other results to calculate the average volume of dilute nitric acid that reacted with the aqueous potassium hydroxide.

$$\frac{18.1 + 18.3 + 18.2}{3} = 18.2\ cm^3$$

(d) The equation for the reaction taking place in the titration is shown.

$$HNO_3 + KOH \rightarrow KNO_3 + H_2O$$

The student concluded that the aqueous potassium hydroxide was more concentrated than the dilute nitric acid.

Explain whether or not the student's conclusion was correct.

HNO_3 is more concentrated
smaller volume of HNO_3 is required

CORRECTION

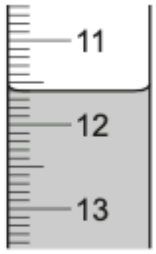
58. A student investigated the reaction between dilute hydrochloric acid and an aqueous solution of sodium carbonate labelled solution L.

Three experiments were done.

Experiment 1

- A measuring cylinder was used to pour 25 cm3 of solution L into a conical flask.
- Ten drops of thymolphthalein indicator were added to the conical flask.
- A burette was filled up to the 0.0 cm3 mark with dilute hydrochloric acid.
- Dilute hydrochloric acid was added from the burette to the conical flask until the solution just changed to colourless at the end-point of the titration.

(a) Use the burette diagram to record the final burette reading in the table and complete the table.



final burette reading

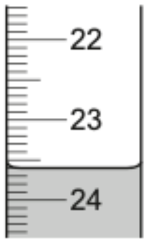
	Experiment 1
final burette reading / cm^3	11.6
initial burette reading / cm^3	0.0
difference / cm^3	11.6

CORRECTION

Experiment 2

- Ten drops of methyl orange indicator were added to the solution in the conical flask from Experiment 1.
- Dilute hydrochloric acid was added from the burette to the conical flask until the solution just changed colour.

(b) Use the burette diagram to record the final burette reading in the table and complete the table.



final burette reading

	Experiment 2
final burette reading / cm^3	23.6
initial burette reading / cm^3	12.0
difference / cm^3	11.6

Experiment 3

- The conical flask was emptied and rinsed with distilled water.
- Experiment 1 was repeated using methyl orange indicator instead of thymolphthalein indicator and adding dilute hydrochloric acid from the burette to the conical flask until the solution just changed colour.

CORRECTION

(c) Use the burette diagrams to record the burette readings in the table and complete the table.

initial burette reading   final burette reading

	Experiment 3
final burette reading / cm^3	24.1
initial burette reading / cm^3	0.9
difference / cm^3	23.2

(d) What colour change was observed in the conical flask in Experiment 3?

yellow to orange

(e) Why was the conical flask emptied and rinsed with distilled water at the start of Experiment 3?

To remove the residue in conical flask

CORRECTION

(f) Complete the sentence.

Experiment ..3.. needed the largest volume of dilute hydrochloric acid to change the colour of the indicator.

(g) Give the name of a more accurate piece of apparatus for measuring the volume of solution L.

pipette

(h) What would be the effect on the results if solution L were warmed before adding the dilute hydrochloric acid? Give a reason for your answer.

No effect

No change in amount of reactant

(i) (i) Determine the simplest whole number ratio of volumes of dilute hydrochloric acid used in Experiments 1 and 3.

1 : 2

CORRECTION

(ii) Suggest why the volumes of dilute hydrochloric acid used in Experiments 1 and 3 are different.

different indicator used.

(j) Suggest why universal indicator cannot be used in these experiments.

more than one color change

cannot identify end-point

(k) Suggest how the reliability of the results could be checked.

repeat experiment

Compare results

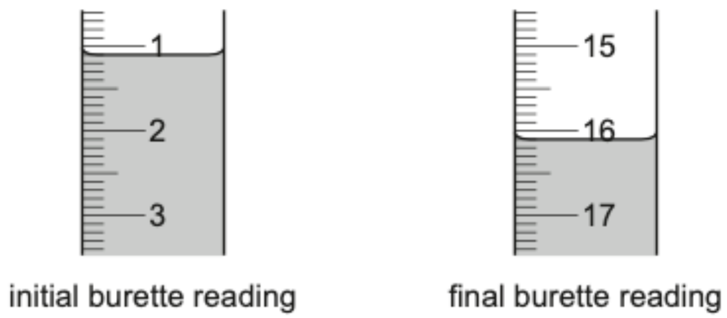
CORRECTION

59. A student investigated the reaction between two different solutions, A and B, of aqueous potassium manganate(VII) and solution C. Three experiments were done.

Experiment 1

- A burette was filled with solution A. The initial burette reading was recorded.
- A measuring cylinder was used to pour 25 cm^3 of solution C into a conical flask.
- Solution A was added to the conical flask until the mixture just turned pink. The final burette reading was recorded.
- About 2 cm^3 of the contents of the conical flask was poured into a test-tube to use in Experiment 3.
- The rest of the contents of the conical flask was poured away. The conical flask was rinsed with distilled water.

(a) Use the burette diagrams to record the burette readings in the table and complete the table.



	Experiment 1
final burette reading / cm^3	16.1
initial burette reading / cm^3	1.1
volume used / cm^3	15.0

CORRECTION

Experiment 2

- The contents of the burette used in Experiment 1 were poured away and the burette was rinsed with distilled water.
- The burette was then rinsed with solution B.
- Experiment 1 was repeated using solution B instead of solution A.

(b) Use the burette diagrams to record the burette readings in the table and complete the table.

initial burette reading   final burette reading

	Experiment 2
final burette reading / cm^3	31.9
initial burette reading / cm^3	1.9
volume used / cm^3	30.0

(c) (i) Which solution of potassium manganate(VII), solution A or solution B, is the more concentrated?

Explain your answer. Solution A.

Less volume of solution A required to react with solution C.

CORRECTION

(ii) How many times more concentrated is this solution of potassium manganate(VII)?

$\frac{30}{15} = 2$ two times

(d) (i) Predict the volume of solution B that would be used if Experiment 2 were repeated using 50 cm³ of solution C.

Explain your answer.

$2 \times 30 = 60\ cm^3$

(ii) Suggest a practical problem that using 50cm³ of solution C could cause. How could this problem be solved?

Volume of potassium manganate will be greater than 50cm³

burette will be refilled.

CORRECTION

(e) Give one advantage and one disadvantage of using a measuring cylinder rather than a pipette for solution C.

advantage of using a measuring cylinder : quick

disadvantage of using a measuring cylinder: less accurate

Experiment 3

The results from Experiment 3 are shown in the table.

tests	observations
Aqueous sodium hydroxide was added to about 2 cm^3 of solution **C**.	green precipitate formed
Aqueous sodium hydroxide was added to the reaction mixture saved from Experiment 1.	red-brown precipitate formed

(f) What conclusions can be drawn about solution C from Experiment 3?

Solution C contains Fe^{2+}

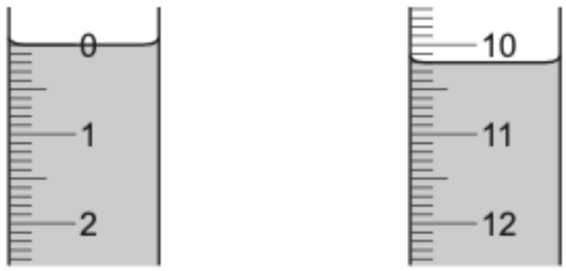
Fe^{2+} is oxidized to Fe^{3+} by manganate.

CORRECTION

60. A student investigated the reaction between dilute hydrochloric acid and three different concentrations of aqueous sodium hydroxide, labelled R, S and T. Three experiments were done.

Experiment 1

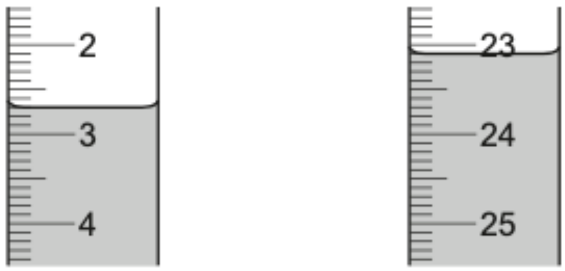
- A burette was filled with dilute hydrochloric acid. The initial burette reading was measured.
- Using a measuring cylinder, 20 cm^3 of solution R was poured into a conical flask.
- Six drops of methyl orange indicator were added to the conical flask.
- Dilute hydrochloric acid was added from the burette, until the solution just changed colour.
- The final burette reading was measured.



initial final

Experiment 2

- Experiment 1 was repeated but using 20 cm^3 of solution S instead of solution R.

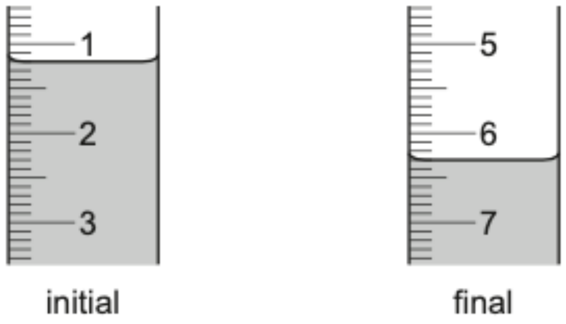


initial final

CORRECTION

Experiment 3

- Experiment 1 was repeated but using 20 cm³ of solution T instead of solution R.



(a) Use the burette diagrams to record all the burette readings in the table.

burette reading/cm³	Experiment 1 using solution **R**	Experiment 2 using solution **S**	Experiment 3 using solution **T**
final burette reading	10.2	23.1	6.3
initial burette reading	0.0	2.7	1.2
volume used	10.2	20.4	5.2

(b) What colour change is observed in the conical flask at the end-point?

From...red.....to...orange....

(c) Suggest why universal indicator is not a suitable indicator in these experiments.

no sharp colour change, and no clear end point.

CORRECTION

(d) (i) Complete the sentences below.

Experiment ....3...... needed the smallest volume of dilute hydrochloric acid to change the colour of the indicator.

Experiment ....2...... needed the largest volume of dilute hydrochloric acid to change the colour of the indicator

(ii) Determine the simplest whole number of ratio of volumes of dilute hydrochloric acid used in Experiments 1 and 2.

Experiment 1 .....1..... : .....2..... Experiment 2

(iii) Deduce the order of concentrations of the solutions of aqueous sodium hydroxide, R, S and T.

most concentrated ....S..............

..............R..............

least concentrated ....T..............

CORRECTION

(e) What would be the effect on the results, if any, if the solutions of aqueous sodium hydroxide were warmed before adding the dilute hydrochloric acid? Give a reason for your answer.

no effect

the mole of reactants are unchanged

(f) Suggest how the reliability of the results could be checked.

repeat

compare results

(g) Suggest a different method, not involving an indicator, of finding the order of concentrations of the solutions of aqueous sodium hydroxide, R, S and T.

Evaporate ⇒ measure the mass of solid

CORRECTION

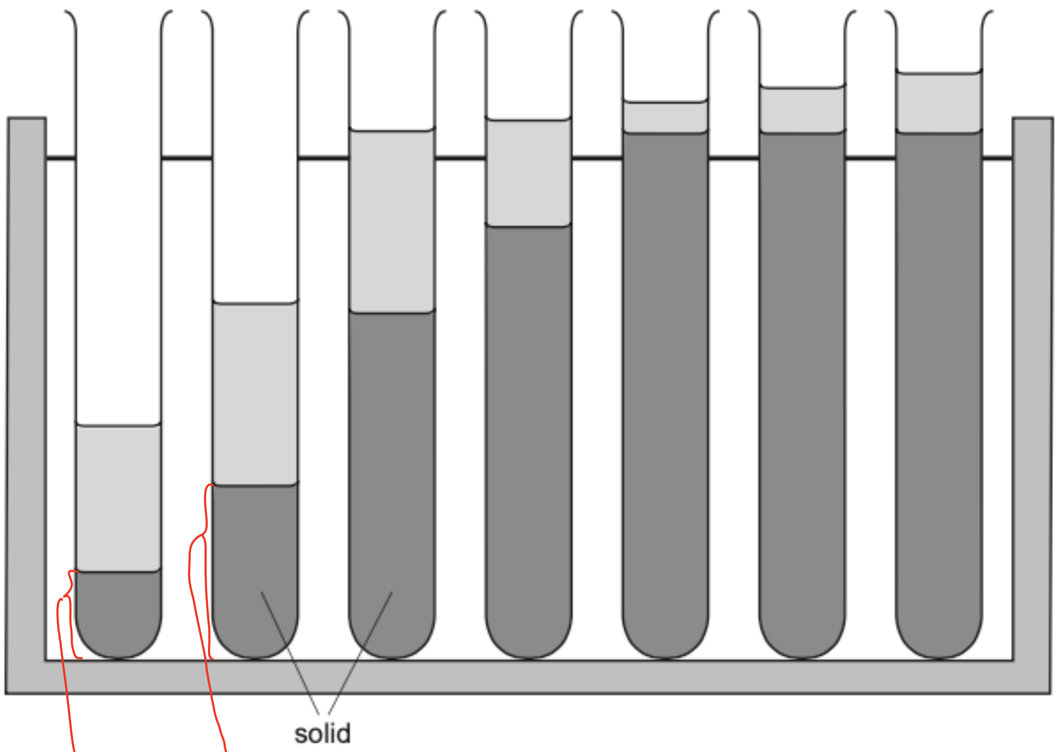
61. A student investigated the reaction between aqueous sodium carbonate and aqueous barium nitrate.

- A burette was filled with aqueous sodium carbonate.
- Seven test-tubes were labelled 1, 2, 3, 4, 5, 6 and 7.
- A measuring cylinder was used to pour 6 cm^3 of aqueous barium nitrate into each of the seven test-tubes in a test-tube rack.
- 1.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 1.
- 2.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 2.
- 4.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 3.
- 5.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 4.
- 6.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 5.
- 7.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 6.
- 8.0 cm^3 of aqueous sodium carbonate was added from the burette to test-tube 7.

A glass rod was used to stir the contents of each of the test-tubes. The contents of the test-tubes were left to stand until the solid formed had settled. A ruler was used to measure the height of the solid formed in each test-tube.

CORRECTION

(a) Use a ruler to measure the heights of the solid formed in each test-tube shown in the diagram. Record the heights of the solid formed in the table and complete the table.

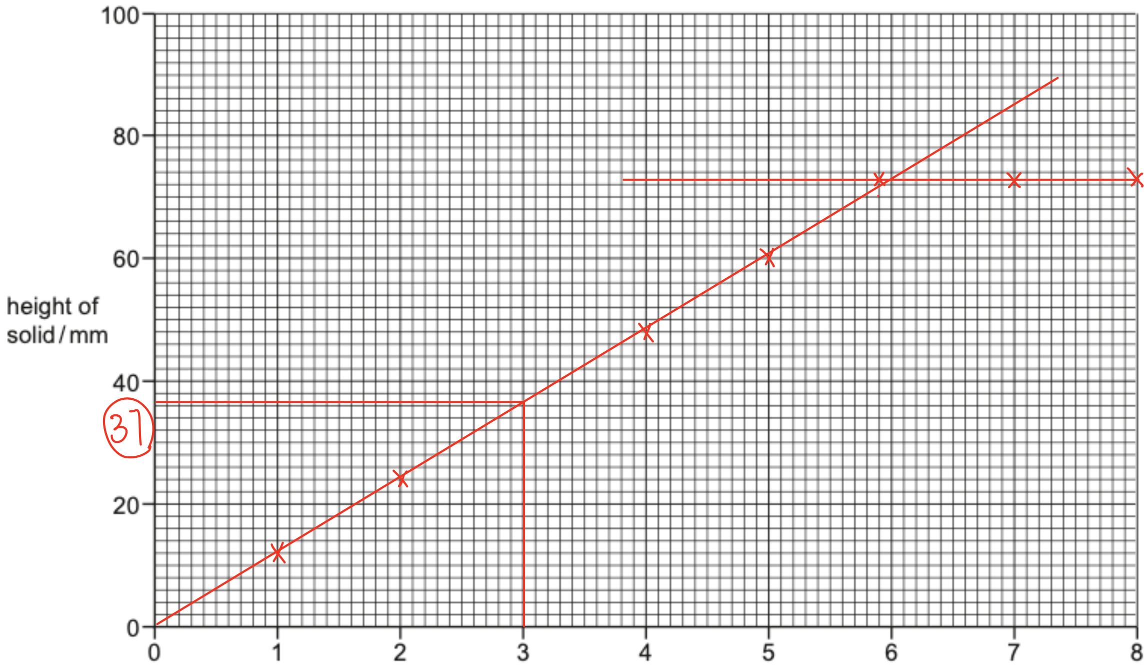


test-tube number	1	2	3	4	5	6	7
volume of aqueous sodium carbonate / cm^3	1	2	4	5	6	7	8
height of solid / mm	12	24	48	60	73	73	73

用尺量出来

CORRECTION

(b) Plot the results on the grid. Draw two intersecting lines of best fit. Label the x-axis.



(c) From your graph, deduce the height of the solid formed when 3.0 cm^3 of aqueous sodium carbonate is added to 6 cm^3 of aqueous barium nitrate.

Show clearly on the grid how you worked out your answer. 37 mm

(d) Describe the trend in the heights of the solids formed in test-tubes 1–7.

height increased

becomes constant

CORRECTION

(e) Predict what would happen if the experiment were continued using three further test-tubes each containing 6 cm^3 of aqueous barium nitrate and separately adding 9.0 cm^3, 10.0 cm^3 and 11.0 cm^3 of aqueous sodium carbonate to each one.

Explain your answer.

same heights

all barium nitrate reacted.

(f) Suggest one change to the apparatus used which could be made to obtain more accurate results.

measuring cylinder ⇒ pipette

(g) Suggest a different method to measure the amount of solid formed during the experiment.

Filteration ⇒ Dry ⇒ weigh solid

(h) Suggest how the reliability of the results could be checked.

repeat experiments

compare results

CORRECTION