1. 5070/21/M/J/16 QA4

(d) Ammonia is used to make fertilisers.

The table gives some information about two fertilisers made from ammonia.

fertiliser	formula	relative formula mass (M_r)
ammonium nitrate	NH_4NO_3	80
urea	$(NH_2)_2CO$	60

Use the data in the table to show that urea contains a greater percentage by mass of nitrogen than ammonium nitrate.

[2]

2. 5070/21/M/J/16 QB8

(d) Cyclohexane can be manufactured from hexane as shown in the equation.

$$C_6H_{14} \rightarrow C_6H_{12} + H_2$$

Calculate the mass of cyclohexane that can be made from 258 g of hexane.
[M_r of cyclohexane = 84]

mass of cyclohexane = ... g [2]

(e) Another cycloalkane has the following percentage composition by mass.

C, 85.7%; H, 14.3%

(i) Use the percentage composition by mass to show that the empirical formula of the cycloalkane is CH_2.

[2]

3. 5070/22/M/J/16 QA2

(c) Dilute hydrofluoric acid reacts with aqueous calcium hydroxide.

$$2HF(aq) + Ca(OH)_2(aq) \rightarrow CaF_2(aq) + 2H_2O(l)$$

What is the minimum volume, in cm^3, of $0.150\,mol/dm^3$ $Ca(OH)_2$ required to react completely with a solution containing 0.200 g of HF?

volume of $Ca(OH)_2(aq)$ = ... cm^3 [3]

4. 5070/22/M/J/16 QA4

(d) Sulfuric acid is used to make the fertiliser potassium sulfate, K_2SO_4.

Calculate the percentage by mass of potassium in this fertiliser.

[2]

5. 5070/22/M/J/16 QB8

(d) Cyclohexene can be manufactured from hexane as shown in the equation.

$$C_6H_{14} \rightarrow C_6H_{10} + 2H_2$$

Calculate the mass of cyclohexene that can be made from 258 g of hexane.
[M_r of cyclohexene = 82]

mass of cyclohexene = ... g [2]

(e) Another cycloalkene has the following percentage composition by mass.

C, 88.2%; H, 11.8%

(i) Use the percentage composition by mass to show that the empirical formula of this cycloalkene is C_5H_8.

[2]

6. 5070/22/M/J/16 QB9

(b) When one mole of methanol, CH_3OH, is formed, 91 kJ of energy is released.

Calculate the amount of energy released when 160 g of methanol is formed.
[M_r of methanol = 32]

energy released = ... kJ [2]

7. 5070/21/M/J/16 QB9

(b) When one mole of hydrogen, H_2, is formed, 131 kJ of energy is absorbed.

Calculate the amount of energy absorbed when 240 dm^3 of hydrogen, measured at room temperature and pressure, is formed.

energy absorbed = ... kJ [2]

8. 5070/21/O/N/16 QA5

Potassium chlorate, $KClO_3$, decomposes to form potassium chloride and oxygen.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

(a) Calculate the percentage by mass of oxygen in potassium chlorate.

[2]

(b) Calculate the maximum volume of oxygen formed at room temperature and pressure when 12.25 g of potassium chlorate is completely decomposed.

[3]

9. 5070/21/O/N/16 QB9

(c) A 9.50 g sample of a chloride of tin contains 5.95 g of tin.

Deduce the empirical formula of this chloride of tin.

empirical formula .....[2]

(d) Tin(II) oxide reacts with oxygen to form tin(IV) oxide.

$$\underset{\text{tin(II) oxide}}{2SnO} + O_2 \rightarrow \underset{\text{tin(IV) oxide}}{2SnO_2}$$

When a sample of 13.5 g of tin(II) oxide is reacted with oxygen, 12.7 g of tin(IV) oxide is formed.

Calculate the percentage yield of tin(IV) oxide.

..... % [3]

10. 5070/21/O/N/16 QB10

A student prepared some crystals of hydrated lithium nitrate by reacting aqueous lithium hydroxide with dilute nitric acid.

$$LiOH + HNO_3 + 2H_2O \rightarrow LiNO_3.3H_2O$$

(b) The student used 20.0 cm^3 of 0.500 mol/dm^3 of lithium hydroxide to prepare the crystals.

Calculate the maximum mass of hydrated lithium nitrate crystals that could be made.

..... g [3]

11. 5070/22/O/N/16 QA5

Nickel carbonyl, $Ni(CO)_4$, reacts with hydrogen iodide.

$$Ni(CO)_4(l) + 2HI(g) \rightarrow NiI_2(s) + H_2(g) + 4CO(g)$$

(a) Calculate the percentage by mass of nickel in nickel carbonyl.

..... % [2]

(b) Calculate the maximum volume of gas formed at room temperature and pressure when 1.71 g of nickel carbonyl reacts completely with hydrogen iodide.

maximum volume of gas formed ..... [3]

12. 5070/22/O/N/16 QB9

(e) A 11.09 g sample of an oxide of copper contains 9.86 g of copper.

Deduce the empirical formula of this oxide of copper.

empirical formula .....[2]

13. 5070/22/O/N/16 QB10

A student prepared some crystals of hydrated copper(II) sulfate by reacting excess insoluble copper(II) oxide with dilute sulfuric acid.

$$CuO + H_2SO_4 + 4H_2O \rightarrow CuSO_4.5H_2O$$

(b) The student used 15.0 cm^3 of 2.00 mol/dm^3 sulfuric acid to prepare the crystals.

Calculate the maximum mass of hydrated copper(II) sulfate crystals that could be made.

..... g [3]

14. 5070/21/M/J/17 QA3

(c) Aqueous sodium sulfate can be used to prepare barium sulfate.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

In an experiment, 20.0 cm^3 of 0.550 mol/dm^3 of barium nitrate was added to excess aqueous sodium sulfate.

(i) Calculate the maximum mass of barium sulfate that could be made.

[The relative formula mass of $BaSO_4$ is 233.]

maximum mass of barium sulfate = ... g [2]

(ii) A mass of 1.92 g of dry barium sulfate was obtained. Calculate the percentage yield of barium sulfate.

percentage yield of barium sulfate = ... % [1]

15. 5070/21/M/J/17 QB7

Copper reacts with concentrated nitric acid.

$$Cu(s) + 4HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2NO_2(g) + 2H_2O(l)$$

(c) An excess of copper is added to 25.0 cm^3 of 16.0 mol/dm^3 HNO_3.

Use this information, together with the equation above, to calculate the volume of NO_2 formed.

The gas volume is measured at room temperature and pressure.

volume of NO_2 = ...[3]

16. 5070/21/M/J/17 QB9

(d) Chemists have discovered that some noble gases can form compounds.

A 1.000 g sample of one of these compounds contains 0.549 g of xenon, 0.134 g of oxygen and 0.317 g of fluorine.

(i) Calculate the empirical formula of this compound.

empirical formula .....[2]

17. 5070/22/M/J/17 QA3

(c) Potassium sulfate can be prepared by reacting aqueous potassium hydroxide with dilute sulfuric acid.

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

In an experiment, 20.0 cm^3 of 0.650 mol/dm^3 sulfuric acid is just neutralised by aqueous potassium hydroxide.

(i) Calculate the maximum mass of potassium sulfate, K_2SO_4, that could be prepared.

[The relative formula mass of K_2SO_4 is 174.]

maximum mass of potassium sulfate = ... g [2]

(ii) After crystallisation, 1.72 g of dry potassium sulfate was obtained. Calculate the percentage yield of potassium sulfate.

percentage yield of potassium sulfate = ... % [1]

18. 5070/22/M/J/17 QB7

Copper reacts with hot concentrated aqueous sulfuric acid.

$$Cu(s) + 2H_2SO_4(aq) \rightarrow CuSO_4(aq) + SO_2(g) + 2H_2O(l)$$

(c) An excess of copper is added to 25.0 cm^3 of hot 14.0 mol/dm^3 H_2SO_4.

Use this information, together with the equation, to calculate the maximum volume of SO_2 formed.

The gas volume is measured at room temperature and pressure.

volume of SO_2 = ...[3]

19. 5070/22/M/J/17 QB9

(d) Ethane reacts with chlorine in the presence of ultraviolet light to give a number of different compounds.

A 1.00 g sample of one of these compounds contains 0.040 g of hydrogen, 0.242 g of carbon and 0.718 g of chlorine.

(i) Calculate the empirical formula of this compound.

empirical formula .....[2]

(ii) The relative molecular mass of the compound is 99.

Deduce the molecular formula of the compound.

.....[1]

20. 5070/21/O/N/17 QA3

(c) Iron(III) oxide can be reduced by carbon monoxide.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

(i) Calculate the maximum mass of iron that can be formed when 14.4 g of iron(III) oxide is reduced by excess carbon monoxide.

Give your answer to three significant figures.

mass of iron = ... g [3]

(ii) Calculate the maximum volume of carbon dioxide, in dm^3, produced by this reaction, at room temperature and pressure.

volume of carbon dioxide = ... dm^3 [2]

21. 5070/21/O/N/17 QB7

(b) A sample containing 64.5 g of a chloride of germanium contains 42.6 g of chlorine.

(i) Deduce the empirical formula of this chloride.

empirical formula .....[3]

22. 5070/21/O/N/17 QB8

Concentrated aqueous ammonia is used to make fertilisers such as ammonium phosphate, $(NH_4)_3PO_4$.

(a) Calculate the percentage by mass of nitrogen in ammonium phosphate.

..... % by mass [2]

(e) Aqueous ammonia reacts with dilute sulfuric acid.

$$2NH_3(aq) + H_2SO_4(aq) \rightarrow (NH_4)_2SO_4(aq)$$

A student titrates 20.0 cm^3 of aqueous ammonia with 0.150 mol/dm^3 sulfuric acid.

10.5 cm^3 of sulfuric acid is required to neutralise the aqueous ammonia.

Calculate the concentration, in mol/dm^3, of the aqueous ammonia.

concentration of aqueous ammonia = ... mol/dm^3 [3]

23. 5070/22/O/N/17 QA3

(c) The equation for the reaction of iron with steam is shown.

$$3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$$

(i) Calculate the maximum mass of Fe_3O_4 that can be formed when 39.2g of iron reacts with excess steam.

Give your answer to three significant figures.

mass of Fe_3O_4 = ... g [3]

(ii) Calculate the maximum volume of hydrogen, in dm^3, produced by this reaction, when measured at room temperature and pressure.

volume of hydrogen = ... dm^3 [2]

24. 5070/22/O/N/17 QB7

(c) A 40.5 g sample of a chloride of sulfur contains 21.3 g of chlorine.

(i) Deduce the empirical formula of this chloride of sulfur.

empirical formula .....[3]

(ii) The relative molecular mass of this chloride is 135.

Deduce the molecular formula of this chloride.

molecular formula .....[1]

25. 5070/22/O/N/17 QB8

Potassium nitrate, potassium sulfate and potassium phosphate are used in fertilisers.

(a) Calculate the percentage by mass of potassium in potassium sulfate, K_2SO_4.

..... % by mass [2]

(e) Dilute phosphoric acid, $H_3PO_4(aq)$, reacts with aqueous potassium hydroxide to make potassium phosphate.

$$H_3PO_4(aq) + 3KOH(aq) \rightarrow K_3PO_4(aq) + 3H_2O(l)$$

A student titrates 25.0 cm^3 of $H_3PO_4(aq)$ with 0.200 mol/dm^3 KOH(aq).

12.5 cm^3 of KOH(aq) is required to react exactly with the $H_3PO_4(aq)$.

Calculate the concentration of the $H_3PO_4(aq)$.

concentration of $H_3PO_4(aq)$ = ... mol/dm^3 [3]

26. 5070/21/M/J/18 Q3

(b) Barium chloride can be prepared by reacting barium carbonate with dilute hydrochloric acid.

$$BaCO_3 + 2HCl \rightarrow BaCl_2 + H_2O + CO_2$$

Excess barium carbonate is reacted with 40.0 cm^3 of 1.50 mol/dm^3 hydrochloric acid.

After purification the percentage yield of barium chloride was 75.0 %.

Calculate the mass of barium chloride prepared.

Give your answer to **three** significant figures.

[M_r: $BaCl_2$, 208]

mass of barium chloride ..... g [3]

27. 5070/21/M/J/18 Q4

(d) Ethanol is used as a fuel.

$$C_2H_5OH + 3O_2 \rightarrow 3H_2O + 2CO_2$$

The complete combustion of one mole of ethanol releases 1350 kJ of energy.

A sample of ethanol reacts with excess oxygen to make 0.240 dm^3 of carbon dioxide, measured at room temperature and pressure.

Calculate the energy released, in kJ, in this reaction.

energy released ..... kJ [2]

28. 5070/21/M/J/18 Q6

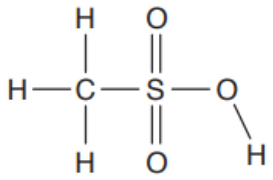
Copper pyrites is an ore containing compounds of copper. One of the compounds in the ore is $CuFeS_2$.

(a) Calculate the mass of copper in 20.0 tonnes of $CuFeS_2$.

mass of copper ..... tonnes [2]

29. 5070/21/M/J/18 Q8

Methanesulfonic acid has the structure shown.



(a) Write the molecular formula for methanesulfonic acid.

.....[1]

(d) What is the mass of methanesulfonic acid needed to make 150 cm^3 of a 0.150 mol/dm^3 solution?

mass ..... g [3]

(e) In a titration, 0.00150 moles of NaOH is exactly neutralised by 0.175 mol / dm^3 methanesulfonic acid.

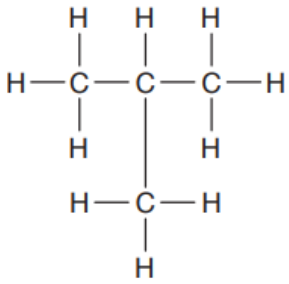
One mole of sodium hydroxide reacts with one mole of methanesulfonic acid.

Calculate the volume, in cm^3, of aqueous methanesulfonic acid needed in this titration.

volume ..... cm^3 [1]

30. 5070/21/M/J/18 Q9

Methylpropane is a saturated hydrocarbon.



methylpropane

(a) Methylpropane reacts with chlorine in the presence of ultraviolet light to give several compounds.

(i) One of these compounds has a relative molecular mass of 127.

What is the molecular formula of this compound?

molecular formula .....

Suggest a structure for this compound. Show all of the atoms and all of the bonds.

[2]

(ii) Another compound formed has the percentage composition by mass:

29.7% carbon; 4.3% hydrogen; 65.9% chlorine.

Calculate the molecular formula for this compound.

molecular formula .....[2]

31. 5070/22/M/J/18 Q3

(c) Silver nitrate can be prepared by reacting silver oxide with dilute nitric acid.

$$Ag_2O + 2HNO_3 \rightarrow 2AgNO_3 + H_2O$$

Excess silver oxide is reacted with 30.0 cm^3 of 0.150 mol/dm^3 nitric acid.

After purification the percentage yield of silver nitrate is 80.0%.

Calculate the mass of silver nitrate prepared.

Give your answer to **three** significant figures.

[M_r: $AgNO_3$, 170]

mass of silver nitrate ..... g [3]

32. 5070/22/M/J/18 Q4

Phosphorus is a non-metal in Group V of the Periodic Table.

(a) Phosphorus can be manufactured from calcium phosphate, $Ca_3(PO_4)_2$.

$$2Ca_3(PO_4)_2 + 6SiO_2 + 10C \rightarrow 6CaSiO_3 + 10CO + P_4$$

What is the maximum mass of phosphorus that can be made using 300 g of silicon dioxide, SiO_2?

mass of phosphorus ..... g [2]

33. 5070/22/M/J/18 Q7

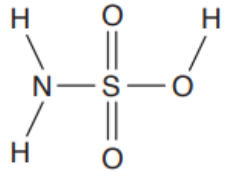
Sphalerite is an ore containing compounds of zinc. One of the compounds in the ore is ZnS.

(a) Calculate the mass of zinc in 30.0 tonnes of ZnS.

mass of zinc ..... tonnes [2]

34. 5070/22/M/J/18 Q9

Sulfamic acid has the structure shown.



(a) Write the molecular formula for sulfamic acid.

.....[1]

(c) What mass of sulfamic acid is required to make 250 cm^3 of a 0.150 mol/dm^3 solution?

mass ..... g [3]

35. 5070/21/O/N/18 Q3

(d) Succinic acid is neutralised by aqueous sodium hydroxide.

$$C_2H_4(COOH)_2 + 2NaOH \rightarrow C_2H_4(COONa)_2 + 2H_2O$$

Calculate the minimum volume of 0.0200 mol/dm^3 sodium hydroxide required to neutralise 25.0 cm^3 of 0.0500 mol/dm^3 succinic acid.

Give your answer to **three** significant figures.

volume ..... cm^3 [3]

36. 5070/21/O/N/18 Q4

(f) A hydrocarbon contains 90% carbon by mass.

(i) Deduce the empirical formula of this hydrocarbon.

empirical formula .....[2]

(ii) What additional piece of information is needed to deduce the molecular formula of this hydrocarbon?

.....[1]

37. 5070/21/O/N/18 Q9

Cerium is a metal with a relative atomic mass of 140.

Cerium powder reacts with sulfuric acid.

$$2Ce(s) + 3H_2SO_4(aq) \rightarrow Ce_2(SO_4)_3(aq) + 3H_2(g)$$

(d) Calculate the maximum volume of hydrogen, in dm^3, formed when 12.6 g of cerium reacts with excess sulfuric acid at room temperature and pressure.

[A_r: Ce, 140]

volume ..... dm^3 [3]

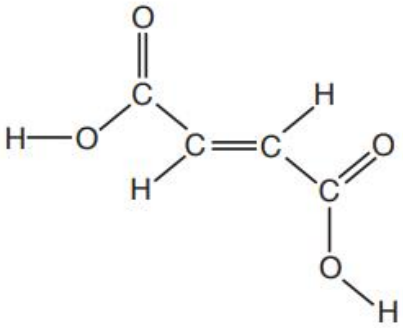
(e) The formula of cerium carbonate is $Ce_2(CO_3)_3$.

Calculate the percentage by mass of cerium in cerium carbonate.

..... % [2]

38. 5070/22/O/N/18 Q3

The structure of fumaric acid is shown.



(c) Fumaric acid is neutralised by aqueous sodium hydroxide.

$$C_2H_2(COOH)_2 + 2NaOH \rightarrow C_2H_2(COONa)_2 + 2H_2O$$

(i) Write the ionic equation for this reaction.

.....[1]

(ii) Calculate the volume of 0.0500 mol/dm^3 sodium hydroxide required to neutralise 20.0 cm^3 of 0.0200 mol/dm^3 fumaric acid.

Give your answer to **three** significant figures.

volume ..... cm^3 [3]

39. 5070/22/O/N/18 Q4

(e) A hydrocarbon contains 85.7% carbon by mass.

(i) Deduce the empirical formula of this hydrocarbon.

[2]

(ii) What other piece of information is needed to deduce the molecular formula of this hydrocarbon?

.....[1]

40. 5070/22/O/N/18 Q9

Sulfuric acid reacts with zinc to form zinc sulfate and hydrogen.

$$Zn(s) + H_2SO_4(aq) \longrightarrow ZnSO_4(aq) + H_2(g)$$

(d) Calculate the maximum volume of hydrogen, in dm^3, formed when 4.55 g of zinc reacts with excess sulfuric acid at room temperature and pressure.

volume ..... dm^3 [2]

(e) The formula of zinc phosphate is $Zn_3(PO_4)_2$.

Calculate the percentage by mass of zinc in zinc phosphate.

..... % [2]

41. 5070/21/M/J/19 Q3

(d) Molybdenum steel is made by reducing a mixture of MoO_3 and Fe_2O_3 with aluminium.

$$MoO_3 + 2Al \rightarrow Mo + Al_2O_3$$

$$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3$$

Molybdenum steel contains 20.0% by mass of molybdenum.

Calculate the mass of MoO_3 needed to make 1000 g of molybdenum steel.

Give the answer to **three** significant figures.

[The relative atomic mass of molybdenum, Mo, is 96.]

mass of MoO_3 ..... g [3]

42. 5070/21/M/J/19 Q5

Acid **U** is a compound containing carbon, hydrogen and oxygen.

(a) A 6.30 g sample of **U** contains 1.68 g of carbon and 0.14 g of hydrogen.

Calculate the empirical formula of **U**.

empirical formula ..... [3]

(b) A 0.086 g sample of **U** is completely neutralised by 12.7 cm^3 of 0.150 mol/dm^3 KOH.

One mole of **U** reacts with two moles of KOH.

Calculate the relative formula mass of **U**.

relative formula mass ..... [3]

(c) What is the molecular formula of **U**?

..... [1]

43. 5070/21/M/J/19 Q7

Ammonium carbonate, $(NH_4)_2CO_3$, is a white solid which decomposes when heated.

$$(NH_4)_2CO_3(s) \rightarrow 2NH_3(g) + CO_2(g) + H_2O(g)$$

(b) Calculate the total volume of ammonia and carbon dioxide, measured at room temperature and pressure, formed when 4.80 g of ammonium carbonate is completely decomposed.

volume of gas ..... [3]

44. 5070/22/M/J/19 Q3

(c) Titanium is made by reducing $TiCl_4$ using magnesium.

$$TiCl_4 + 2Mg \rightarrow 2MgCl_2 + Ti$$

Calculate the mass of titanium made from 1000 g of $TiCl_4$.

The reaction has a 90% percentage yield.

Give the answer to **two** significant figures.

[The relative atomic mass of titanium, Ti, is 48.]

mass of Ti ..... g [3]

45. 5070/22/M/J/19 Q5

W is a compound containing carbon, hydrogen and oxygen.

(a) **W** contains 57.1% carbon and 4.8% hydrogen by mass.

Calculate the empirical formula of **W**.

empirical formula ..... [3]

(b) A 0.194 g sample of **W** reacts completely with 18.5 cm^3 of 0.250 mol/dm^3 KOH.

One mole of **W** reacts with three moles of KOH.

Calculate the relative formula mass of **W**.

relative formula mass ..... [3]

(c) Deduce the molecular formula of **W**.

..... [1]

46. 5070/22/M/J/19 Q7

Ammonium iodide, NH_4I, is a white solid which decomposes when heated.

$$NH_4I(s) \rightarrow NH_3(g) + HI(g)$$

(b) Calculate the volume of gas, measured at room temperature and pressure, formed when 2.90 g of ammonium iodide is completely decomposed.

volume of gas ..... [3]

47. 5070/21/O/N/19 Q2

(c) The equation shows the reaction of sodium with water.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

Calculate the minimum mass of sodium, in grams, needed to produce 300 cm^3 of hydrogen gas at room temperature and pressure.

Give your answer to **three** significant figures.

mass of sodium ..... g [3]

48. 5070/21/O/N/19 Q3

(c) A copper compound contains 21.09% copper, 43.82% caesium and 35.09% chlorine by mass.
Use this information to deduce the empirical formula of this copper compound.

empirical formula ..... [2]

49. 5070/21/O/N/19 Q5

(d) Hydrated nickel(II) chloride has the formula $NiCl_2.xH_2O$.
It has a relative formula mass of 238.

Calculate the value of x in this formula.
[The relative atomic mass of nickel, Ni, is 59]

x = ... [2]

50. 5070/21/O/N/19 Q6

(d) The equation for the reaction of ethanoic acid with sodium carbonate is shown.

$$2CH_3COOH + Na_2CO_3 \rightarrow 2CH_3COONa + CO_2 + H_2O$$

A student added 3.18 g of sodium carbonate to 224 cm^3 of 0.250 mol / dm^3 ethanoic acid.

Show by calculation that sodium carbonate is in excess.

[3]

51. 5070/22/O/N/19 Q4

The equation shows the reaction of calcium carbonate with hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$$

(d) Calculate the minimum mass of calcium carbonate, in grams, needed to produce 16.8 cm^3 of carbon dioxide at room temperature and pressure.

Give your answer to **three** significant figures.

mass of calcium carbonate ..... g [2]

52. 5070/22/O/N/19 Q5

(d) Hydrated sodium iodate(V) has the formula $NaIO_3.xH_2O$.
It has a relative formula mass of 288.

Calculate the value of x in this formula.

x = ... [2]

53. 5070/22/O/N/19 Q6

(d) The equation for the reaction of butanoic acid with sodium carbonate is shown.

$$2C_3H_7COOH + Na_2CO_3 \rightarrow 2C_3H_7COONa + CO_2 + H_2O$$

A student added 5.28 g of butanoic acid to 56.0 cm^3 of 0.500 mol/dm^3 sodium carbonate.

Show by calculation that butanoic acid is in excess.

[3]

54. 5070/21/M/J/20 Q3

The equation for the decomposition of hydrogen peroxide is shown.

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

A sample containing 1.00 mol of hydrogen peroxide is completely decomposed.

This sample releases 98.0 kJ of heat energy.

(a) Calculate the heat energy released when 680 g of hydrogen peroxide is completely decomposed.

heat energy released ..... kJ [2]

55. 5070/21/M/J/20 Q8

(c) Anhydrous aluminium chloride contains 20.2% by mass of aluminium.

(i) Show that the empirical formula for anhydrous aluminium chloride is $AlCl_3$.

[2]

(ii) A sample of anhydrous aluminium chloride has a mass of 2.34 g.

The sample contains 0.00876 mol of anhydrous aluminium chloride.

Calculate the relative molecular mass and give the molecular formula for anhydrous aluminium chloride.

relative molecular mass .....

molecular formula .....

[2]

56. 5070/21/M/J/20 Q9

(c) Iron(II) sulfate thermally decomposes to form iron(III) oxide, sulfur dioxide and sulfur trioxide.

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

(ii) A sample of 6.08 g of $FeSO_4$ is heated until all the sample has thermally decomposed.

Calculate the volume of sulfur dioxide formed, $SO_2(g)$, in dm^3, measured at room temperature and pressure.

volume of sulfur dioxide ..... dm^3 [3]

57. 5070/22/M/J/20 Q2

Hydrogen reacts with oxygen as shown in the equation.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$$

A sample containing 1.00 mol of hydrogen, H_2, is completely combusted.

This sample releases 286 kJ of heat energy.

(a) Calculate the heat energy released when 25.0 g of hydrogen is completely combusted.

heat energy released ..... kJ [2]

58. 5070/22/M/J/20 Q3

(d) Methyl propanoate is prepared by the reaction between propanoic acid and methanol.

$$CH_3CH_2CO_2H + CH_3OH \rightleftharpoons CH_3CH_2COOCH_3 + H_2O$$

The forward reaction is exothermic.

(i) Calculate the maximum mass of methyl propanoate that can be made from 11.0 g of propanoic acid and excess methanol.

Give the answer to **three** significant figures.

mass of methyl propanoate ..... g [2]

59. 5070/22/M/J/20 Q7

(c) An oxide of phosphorus contains 43.7% by mass of phosphorus.

(i) Show that the empirical formula for this oxide is P_2O_5.

[2]

(ii) A sample of this oxide has a mass of 2.56 g.

The sample contains 0.00901 mol of the oxide.

Calculate the relative molecular mass and hence the molecular formula for this oxide of phosphorus.

relative molecular mass .....

molecular formula .....

[2]

60. 5070/22/M/J/20 Q8

(c) Anhydrous copper(II) sulfate decomposes when heated strongly.

$$CuSO_4(s) \rightarrow CuO(s) + SO_3(g)$$

A sample of 6.40 g of $CuSO_4$ is heated until all of the sample has thermally decomposed.

Calculate the volume of sulfur trioxide formed, in dm^3, measured at room temperature and pressure.

volume of sulfur trioxide ..... dm^3 [3]

61. 5070/21/O/N/20 Q3

(e) A 2.25 g sample of an oxide of copper contains 0.250 g of oxygen.

Deduce the empirical formula of this oxide of copper.

[3]

62. 5070/21/O/N/20 Q4

(d) Fluorine reacts with aqueous sodium hydroxide to produce sodium fluoride, NaF, water and oxygen.

$$2F_2 + 4NaOH \rightarrow 4NaF + 2H_2O + O_2$$

Calculate the maximum volume of oxygen produced, in dm^3, at room temperature and pressure, when 0.037 mol of sodium hydroxide react completely with fluorine.

Give your answer to **two** significant figures.

volume of oxygen ..... dm^3 [2]

63. 5070/21/O/N/20 Q7

(b) Aluminium can also be produced on a small scale by reacting aluminium oxide with magnesium.

$$Al_2O_3 + 3Mg \rightarrow 2Al + 3MgO$$

(ii) Calculate the maximum mass of aluminium formed when 25.5 g of aluminium oxide reacts with excess magnesium.

mass of aluminium = ... g [2]

64. 5070/21/O/N/20 Q8

(a) Dilute nitric acid reacts with aqueous barium hydroxide.

$$2HNO_3(aq) + Ba(OH)_2(aq) \rightarrow Ba(NO_3)_2(aq) + 2H_2O(l)$$

(i) A student titrates 25.0 cm^3 of dilute nitric acid with 0.0450 mol/dm^3 barium hydroxide using methyl orange as an indicator.

A volume of 34.0 cm^3 of aqueous barium hydroxide reacts exactly with the dilute nitric acid.

Calculate the concentration of the dilute nitric acid.

concentration of nitric acid ..... mol/dm^3 [3]

65. 5070/22/O/N/20 Q2

(e) A 36.3 g sample of a compound contains 14.4 g carbon, 0.600 g hydrogen and 21.3 g chlorine.

(i) Calculate the empirical formula of this compound.

[2]

(ii) The relative molecular mass of this compound is 181.5.

Deduce the molecular formula of this compound.

[1]

66. 5070/22/O/N/20 Q4

(d) Water and oxygen are formed when aqueous hydrogen peroxide decomposes.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

Calculate the maximum volume of oxygen, at room temperature and pressure, which is produced by the complete decomposition of a solution containing 16.0 g of hydrogen peroxide.

Give your answer to **three** significant figures.

volume of oxygen ..... dm^3 [3]

67. 5070/22/O/N/20 Q7

(c) Carbon dioxide reacts with hot coke to form carbon monoxide.

The carbon monoxide reduces the iron(III) oxide in the iron ore.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

(ii) Calculate the maximum mass of iron formed when 12.5g of iron(III) oxide react with excess carbon monoxide.

mass of iron ..... g

[2]

68. 5070/22/O/N/20 Q8

This question is about some compounds of sulfur.

(a) Dilute sulfuric acid reacts with aqueous sodium hydroxide as shown.

$$H_2SO_4(aq) + 2NaOH(aq) \rightarrow Na_2SO_4(aq) + 2H_2O(l)$$

(i) A student titrates $25.0\,cm^3$ of dilute sulfuric acid with sodium hydroxide of concentration $0.0150\,mol/dm^3$, using litmus as an indicator.

A volume of $24.0\,cm^3$ of aqueous sodium hydroxide reacts exactly with the dilute sulfuric acid.

Calculate the concentration of the dilute sulfuric acid.

concentration of dilute sulfuric acid ..... mol/dm^3

[3]

69. 5070/21/M/J/21 Q2

(e) Xenon forms a compound that contains only xenon, oxygen and fluorine.

The compound contains 22.1% oxygen by mass and 17.5% fluorine by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [3]

(f) A sample of neon has a volume of 21 dm^3 at room temperature and pressure.

(iii) Calculate the mass of neon in the 21 dm^3 sample.

Give your answer to **two** significant figures.

mass ..... g [2]

70. 5070/21/M/J/21 Q7

Aqueous ammonium nitrite, $NH_4NO_2(aq)$, decomposes when heated, as shown.

$$NH_4NO_2(aq) \longrightarrow N_2(g) + 2H_2O(l)$$

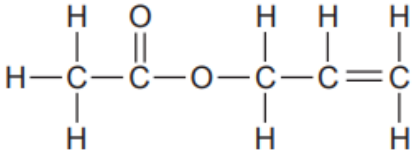
(a) A 25.0 cm^3 sample of 0.150 mol/dm^3 $NH_4NO_2(aq)$ is heated.

Calculate the maximum volume, in dm^3, of nitrogen formed, measured at room temperature and pressure.

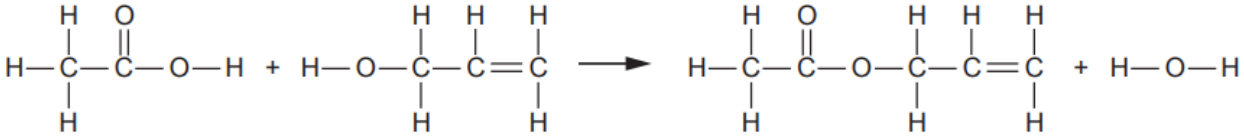
volume of nitrogen ..... dm^3 [2]

71. 5070/21/M/J/21 Q9

The structure of propenyl ethanoate is shown.



(c) Propenyl ethanoate is prepared by the reaction between a carboxylic acid and an alcohol, as shown.



(d) In an experiment 11.6 g of the alcohol is reacted with an excess of the carboxylic acid. The experimental yield of propenyl ethanoate is 6.72 g.

[The relative formula mass of propenyl ethanoate is 100.]

(i) Show that the maximum possible yield of propenyl ethanoate is 20.0 g.

[3]

(ii) Calculate the percentage yield of propenyl ethanoate in this experiment.

% yield ..... [1]

72. 5070/22/M/J/21 Q2

(d) Selenium forms a compound that contains only selenium, oxygen and chlorine.

The compound contains 9.6% oxygen by mass and 42.8% chlorine by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [3]

(e) A sample of oxygen has a volume of 11.5 dm^3 at room temperature and pressure.

(iii) Calculate the mass of oxygen in the 11.5 dm^3 sample at room temperature and pressure.

Give your answer to **two** significant figures.

mass ..... g [2]

73. 5070/22/M/J/21 Q7

Sulfamic acid, NH_2SO_3H, is a white crystalline solid.

It reacts with aqueous sodium nitrite to make nitrogen gas, as shown in the equation.

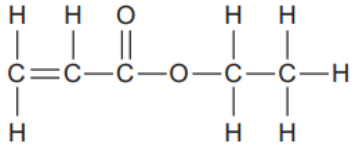
$$NH_2SO_3H(s) + NaNO_2(aq) \longrightarrow N_2(g) + H_2O(l) + NaHSO_4(aq)$$

(a) An excess of sulfamic acid reacts with a $20.0\,cm^3$ sample of $0.150\,mol/dm^3$ $NaNO_2(aq)$.

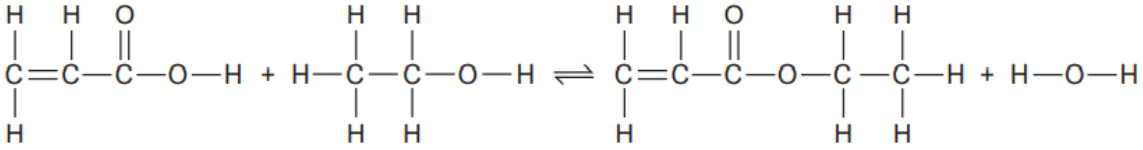
Calculate the maximum volume, in dm^3, of nitrogen formed, measured at room temperature and pressure.

volume of nitrogen ..... dm^3 [2]

The structure of ethyl propenoate is shown.



Ethyl propenoate is prepared by the reversible reaction between a carboxylic acid and an alcohol, as shown.



(d) In an experiment 10.8 g of the carboxylic acid is reacted with an excess of the alcohol. The experimental yield of ethyl propenoate is 9.45 g.

[The relative formula mass of the carboxylic acid is 72.]

(i) Show that the maximum possible yield of ethyl propenoate is 15.0 g.

[3]

(ii) Calculate the percentage yield of ethyl propenoate in this experiment.

% yield ..... [1]

75. 5070/21/O/N/21 Q3

Iron powder reacts with dilute sulfuric acid.

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

(c) Calculate the maximum volume, in dm^3, of hydrogen formed when 3.36 g of iron react with excess dilute sulfuric acid at room temperature and pressure.
Give your answer to **three** significant figures.

maximum volume = ... dm^3 [2]

76. 5070/21/O/N/21 Q4

(d) An organic compound contains 54.5% carbon, 9.10% hydrogen and 36.4% oxygen by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

77. 5070/21/O/N/21 Q9

(b) Ammonia is formed when aqueous ammonium sulfate is heated with sodium hydroxide.

$$(NH_4)_2SO_4 + 2NaOH \rightarrow 2NH_3 + Na_2SO_4 + 2H_2O$$

A student adds 4.50 g of sodium hydroxide to 50.0 cm^3 of 1.25 mol / dm^3 aqueous ammonium sulfate.

Show by calculation that the ammonium sulfate is in excess.

[3]

78. 5070/22/O/N/21 Q3

Magnesium ribbon reacts with dilute hydrochloric acid.

$$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$$

(c) Calculate the maximum volume, in dm^3, of hydrogen formed when 1.68 g of magnesium react with excess dilute hydrochloric acid at room temperature and pressure.
Give your answer to **three** significant figures.

volume = ... dm^3 [2]

79. 5070/22/O/N/21 Q4

(d) A hydrocarbon contains 88.9% carbon by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

80. 5070/22/O/N/21 Q9

(c) Dilute sulfuric acid reacts with sodium hydroxide.

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

A student adds 0.76 g of solid sodium hydroxide to 45 cm^3 of 0.20 mol/dm^3 sulfuric acid.

Show by calculation that the sodium hydroxide is in excess.

[3]

81. 5070/21/M/J/22 Q2

Nitrogen exists as a diatomic molecule, N_2.

(f) Calculate the volume, in dm^3, of 19.2 g of nitrogen at room temperature and pressure.

Give your answer to **two** significant figures.

volume ..... dm^3 [3]

82. 5070/21/M/J/22 Q5

Iron reacts with steam and with dilute sulfuric acid.

$$3Fe(s) + 4H_2O(g) \rightleftharpoons Fe_3O_4(s) + 4H_2(g)$$

b) (iii) The aqueous iron(II) sulfate formed is crystallised to make hydrated iron(II) sulfate, $FeSO_4 \cdot 7H_2O$.

Calculate the relative formula mass of hydrated iron(II) sulfate.

relative formula mass = ... [1]

(iv) A student uses 2.80 g of iron to make 12.5 g of hydrated iron(II) sulfate crystals.

This is a 90% yield.

Calculate the mass of hydrated iron(II) sulfate crystals made from 2.80 g of iron if the yield is 100%.

mass = ... g [1]

83. 5070/21/M/J/22 Q7

(e) A sample of 2.34 g of aluminium is reacted with 50.0 cm^3 of 2.00 mol / dm^3 sulfuric acid.

$$2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$$

Show by calculation that the aluminium is in excess in this reaction.

[3]

84. 5070/22/M/J/22 Q2

(f) Calculate the volume, in dm^3, of 30.2 g of oxygen at room temperature and pressure.

Give your answer to **two** significant figures.

volume ..... dm^3 [3]

85. 5070/22/M/J/22 Q6

(c) The aqueous aluminium sulfate formed is crystallised to make hydrated aluminium sulfate, $Al_2(SO_4)_3 \cdot xH_2O$.

The relative formula mass of hydrated aluminium sulfate is 666.

Calculate the value of x in the formula $Al_2(SO_4)_3 \cdot xH_2O$.

x = ... [2]

86. 5070/22/M/J/22 Q8

(d) A sample of 2.34 g of zinc is reacted with 50.0 cm^3 of 2.00 mol / dm^3 hydrochloric acid.

$$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$$

Show by calculation that the hydrochloric acid is in excess in this reaction.

[3]

87. 5070/21/O/N/22 Q3

(e) Alkenes react with bromine to form compounds containing carbon, hydrogen and bromine.

(i) A compound contains 22.2% carbon, 3.70% hydrogen and 74.1% bromine by mass.

Calculate the empirical formula of this compound.

empirical formula ..... [2]

(ii) A different compound of carbon, hydrogen and bromine has the empirical formula C_3H_2Br.

The relative molecular mass of this compound is 236.

Deduce the molecular formula of this compound.

molecular formula ..... [1]

88. 5070/21/O/N/22 Q4

(b) Ammonium phosphate, $(NH_4)_3PO_4$, is a fertiliser.

Calculate the percentage by mass of nitrogen in ammonium phosphate.

Give your answer to **three** significant figures.

percentage by mass = ... [3]

89. 5070/21/O/N/22 Q9

(a) Zinc powder reacts with dilute hydrochloric acid.

$$Zn + 2HCl \rightarrow ZnCl_2 + H_2$$

When 20.0 cm^3 of dilute hydrochloric acid is added to excess zinc, the volume of hydrogen gas produced at room temperature and pressure is 60.0 cm^3.

(i) Calculate the concentration, in mol/dm^3, of the dilute hydrochloric acid.

concentration ..... mol/dm^3 [3]

90. 5070/22/O/N/22 Q9

(a) Magnesium carbonate reacts with dilute hydrochloric acid.

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

When 25.0 cm^3 of dilute hydrochloric acid is added to excess magnesium carbonate, the volume of carbon dioxide gas produced at room temperature and pressure is 120 cm^3.

(i) Calculate the concentration, in mol/dm^3, of the dilute hydrochloric acid.

concentration ..... mol/dm^3 [3]