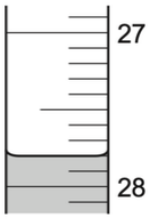
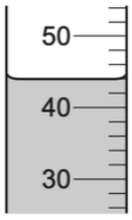
Calculation

1. The diagrams show liquids in a burette and a measuring cylinder.



burette



measuring cylinder

Which row shows the correct readings for the burette and the measuring cylinder?

	burette	measuring cylinder
A	27.8 ✓	42
B	27.8 ✓	44 ✓
C	28.2	42
D	28.2	44

2. The gas hydrazine has the molecular formula N_2H_4.

Hydrazine burns in air to form nitrogen gas and steam.

$$N_2H_4(g) + O_2(g) \rightarrow N_2(g) + 2H_2O(g)$$

Which statements are correct?

1 1 mole of hydrazine gives 72 dm^3 of gaseous products when it reacts with oxygen at room temperature and pressure. 3 x 24 ✓

2 The empirical formula of hydrazine is NH_2. ✓

3 The total number of atoms in 1 mole of hydrazine is 6 × the Avogadro constant. ✓

4 The volume of 1 mole of hydrazine at room temperature and pressure is 6 × 24 dm^3. ✗

A 1, 2 and 3 **B** 1 and 2 only **C** 2, 3 and 4 **D** 3 and 4 only

3. Copper(II) carbonate is broken down by heating to form copper(II) oxide and carbon dioxide gas.

The equation for the reaction is shown.

$$CuCO_3 \rightarrow CuO + CO_2$$

$M(CuCO_3) = 64 + 12 + 3 \times 16 = 124$

$\frac{31.0}{124} = 0.25 \times (64 + 16) = 20$

31.0 g of copper(II) carbonate are heated until all of the contents of the test-tube have turned from green to black.

The yield of copper(II) oxide formed is 17.5 g.

$\frac{17.5}{20} = 87.5\%$

What is the percentage yield?

A 19.02% **B** 21.88% **C** 56.50% **D** 87.50%

4. Aluminium reacts with fluorine.

$$x\mathit{Al}(s) + yF_2(g) \rightarrow z\mathit{AlF}_3(s)$$

Which values of *x*, *y* and *z* balance the equation?

	x	*y*	*z*
A	1	2	1
B	2	3	2
C	3	2	3
D	4	3	4

5. Carbon monoxide burns in oxygen to produce carbon dioxide.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

Which mass of carbon dioxide is produced from 14 g of carbon monoxide?

A 22 g **B** 28 g **C** 44 g **D** 88 g

6. Which equations are balanced?

1 $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$

2 $ZnCO_3 + 2HCl \rightarrow ZnCl_2 + CO_2 + H_2O$

3 $Mg(NO_3)_2 + NaOH \rightarrow Mg(OH)_2 + 2NaNO_3$

4 $CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + H_2O + CO_2$

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

7. Calcium carbide, CaC_2, reacts with water to form ethyne, C_2H_2, and calcium hydroxide.

The equation for the reaction is shown.

$$CaC_2(s) + 2H_2O(l) \rightarrow C_2H_2(g) + Ca(OH)_2(s)$$

Which volume of ethyne is produced when 6 g of water react completely with calcium carbide?

A 4 dm^3 **B** 8 dm^3 **C** 36 dm^3 **D** 72 dm^3

8. Aqueous iron(III) sulfate and aqueous sodium hydroxide react to give a precipitate of iron(III) hydroxide and a solution of sodium sulfate.

What is the balanced equation for this reaction?

A $Fe_2(SO_4)_3(aq) + 2NaOH(aq) \rightarrow Fe(OH)_3(s) + Na_2SO_4(aq)$

B $Fe_2(SO_4)_3(aq) + 3NaOH(aq) \rightarrow Fe(OH)_3(s) + 3Na_2SO_4(aq)$

C $Fe_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow 2Fe(OH)_3(s) + 3Na_2SO_4(aq)$

D $2Fe_2(SO_4)_3(aq) + 6NaOH(aq) \rightarrow 4Fe(OH)_3(s) + 6Na_2SO_4(aq)$

9. The equation for the reaction between sodium carbonate and dilute hydrochloric acid is shown.

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

What is the maximum volume of carbon dioxide produced when 26.5 g of sodium carbonate react with dilute hydrochloric acid?

$\frac{26.5}{106} = 0.25\ mol \times 24 = 6$

A $6\,dm^3$ **B** $12\,dm^3$ **C** $18\,dm^3$ **D** $24\,dm^3$

10. A student put $25.0\,cm^3$ of dilute hydrochloric acid into a conical flask.

The student added 2.5 g of solid sodium carbonate and measured the change in temperature of the mixture.

Which apparatus does the student need to use to obtain the most accurate results?

A balance, measuring cylinder, thermometer

B balance, pipette, stopwatch

C balance, pipette, thermometer

D burette, pipette, thermometer

11. The equation for the reaction between barium chloride solution and dilute sulfuric acid is shown.

$$BaCl_2 + H_2SO_4 \rightarrow BaSO_4 + 2HCl$$

Which row shows the state symbols for this equation?

	$BaCl_2$	H_2SO_4	$BaSO_4$	$2HCl$
A	(aq)	(aq)	(s)	(aq)
B	(aq)	(l)	(s)	(aq)
C	(l)	(aq)	(s)	(l)
D	(aq)	(l)	(aq)	(l)

12. A compound is analysed and found to contain 85.7% carbon and 14.3% hydrogen.

What is its empirical formula?

$\frac{85.7}{12} : \frac{14.3}{1} = 7.14 : 14.3 = 1 : 2$

A CH **B** CH_2 **C** C_2H_4 **D** C_6H

13. The equation for the reaction between phosphorus and oxygen is shown.

$$\overset{1}{x}P_4 + \overset{5}{y}O_2 \rightarrow \overset{2}{z}P_2O_5$$

Which values of *x*, *y* and *z* balance the equation?

	x	*y*	*z*
A	1	5	2
B	1	10	2
C	2	5	2
D	2	10	1

14. The relative molecular mass of an alcohol is 88.

Its percentage composition by mass is: C, 54.5%; H, 9.1%; O, 36.4%.

Which row shows the empirical formula and molecular formula for this alcohol?

	empirical formula	molecular formula
A	C_2H_4O	C_2H_4O
B	C_2H_4O	$C_4H_8O_2$
C	$C_4H_8O_2$	$C_4H_8O_2$
D	$C_4H_8O_2$	C_2H_4O

$\frac{54.5}{12} : 9.1 : \frac{36.4}{16}$

$= 4.54 : 9.1 : 2.275$

$= 2 : 4 : 1$

$C_2H_4O \Rightarrow 12\times2+4+16 = 44$

15. A compound contains 34.5% calcium, 24.1% silicon and 41.4% oxygen by mass.

What is its empirical formula? $\frac{34.5}{40} : \frac{24.1}{28} : \frac{41.4}{16} = 0.863 : 0.860 : 2.59 = 1 : 1 : 3$

A Ca_2SiO_3 B $CaSiO_3$ C $CaSi_2O_3$ D $CaSiO_6$

16. Which quantities of chemicals will react exactly with no reactants left over?

A 12 g of carbon and 12 g of oxygen

B 12 g of carbon and 48 g of oxygen

C 12 g of magnesium and 16 g of oxygen

D 24 g of magnesium and 16 g of oxygen

$C + O_2 \rightarrow CO_2$

12 32

$2Mg + O_2 \rightarrow 2MgO$

48 32

24 16

17. A compound, X, contains 40.0% carbon, 6.7% hydrogen and 53.3% oxygen by mass.

The relative molecular mass, M_r, of X is 60.

What is the molecular formula of X?

$\frac{40.0}{12} : \frac{6.7}{1} : \frac{53.3}{16}$

$= 3.33 : 6.7 : 3.33 = 1 : 2 : 1$

CH_2O

$12+2+16 = 30$

$C_2H_4O_2$

A CH_2O B CH_4O C C_2H_4O D $C_2H_4O_2$

18. 25 cm^3 of 0.1 mol/dm^3 hydrochloric acid exactly neutralise 20 cm^3 of aqueous sodium hydroxide.

The equation for this reaction is:

$$NaOH + HCl \rightarrow NaCl + H_2O$$

What is the concentration of the sodium hydroxide solution?

$n(HCl) = 25\times10^{-3}\times0.1 = 2.5\times10^{-3}$

$n(NaOH) = 2.5\times10^{-3}$

$\frac{2.5\times10^{-3}}{20\times10^{-3}} = 0.125$

A 0.080 mol/dm^3

B 0.800 mol/dm^3

C 0.125 mol/dm^3

D 1.25 mol/dm^3

19. A sample of 16.0 g of a metal oxide, MO, is reduced to 12.8 g of the metal, M.

What is the relative atomic mass, A_r, of M?

$m(O) = 16.0 - 12.8 = 3.2g$

$n(O) = \frac{3.2}{16} = 0.2mol$

$n(M) = 0.2mol$

$M = \frac{12.8}{0.2} = 64$

A 32 B 64 C 80 D 128

20. The equation for the reaction between calcium carbonate and hydrochloric acid is shown.

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

0.001 mol 0.001 mol

How many moles of calcium carbonate will give 24 cm^3 of carbon dioxide when reacted with an excess of the acid?

0.001 mol

A 1 mol **B** 0.1 mol **C** 0.01 mol **D** 0.001 mol

21. Analysis of a compound formed between magnesium and nitrogen showed it contained 14.4 g of magnesium and 5.6 g of nitrogen.

$\frac{14.4}{24} : \frac{5.6}{14}$

$= 0.6 : 0.4$

$= 3 : 2$

What is the empirical formula of the compound?

A Mg_2N_3 **B** Mg_3N_2 **C** Mg_4N_6 **D** Mg_6N_4

22. An excess of zinc is added to 100 cm^3 of 1.0 mol / dm^3 hydrochloric acid.

$n(HCl) = 0.1$ mol

The equation for the reaction is:

$V = \frac{1}{2} \times 0.1 \times 24 = 1.2$

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

What is the maximum volume of hydrogen evolved at room temperature and pressure?

A 1.2 dm^3 **B** 2.0 dm^3 **C** 2.4 dm^3 **D** 24 dm^3

23. Benzene is a liquid with molecular formula C_6H_6.

Ethene is a gas with molecular formula C_2H_4.

Which statement is correct?

A 1 mole of benzene and 1 mole of ethene contain the same number of atoms. ✗

B 1 mole of benzene and 1 mole of ethene both have a volume of 24 dm^3 at room temperature and pressure. ✗

C Both benzene and ethene have the same empirical formula. ✗

D The number of carbon atoms in 0.5 moles of ethene is equal to the Avogadro constant. ✓

24. Sodium hydrogencarbonate undergoes thermal decomposition as shown.

$$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$$

$0.05 \times 106 = 5.3$ g

What is the maximum mass of sodium carbonate that can be made from 0.100 moles of sodium hydrogencarbonate?

A 4.15 g **B** 5.30 g **C** 10.6 g **D** 21.2 g

25. Which sample contains the greatest number of molecules?

A 4 g of hydrogen $\frac{4}{2} = 2$ mol

B 18 g of water $\frac{18}{18} = 1$ mol

C 24 dm^3 of oxygen 1 mol

D 66 g of carbon dioxide $\frac{66}{44} = 1.5$ mol

26. Sodium carbonate solution reacts with dilute hydrochloric acid. The equation for the reaction is shown.

$$Na_2CO_3(aq) + 2HCl(aq) \rightarrow 2NaCl(aq) + CO_2(g) + H_2O(l)$$

Excess sodium carbonate is added to 10.0 cm^3 of 0.10 mol/dm^3 hydrochloric acid.

Which volume of carbon dioxide gas is made?

A 12 cm^3 **B** 24 cm^3 **C** 12 000 cm^3 **D** 24 000 cm^3

27. The equation shows the complete combustion of propane.

$$C_3H_8(g) + 5O_2(g) \rightarrow 3CO_2(g) + 4H_2O(l)$$

Which statement is correct?

A 10 cm^3 of propane cannot burn if less than 50 cm^3 of oxygen is present.

B 10 cm^3 of propane would produce 40 cm^3 of liquid water.

C 100 cm^3 of oxygen would be sufficient to react completely with 20 cm^3 of propane.

D This reaction would result in an increase in the volume of gas.

28. Sodium hydroxide reacts with sulfuric acid.

The equation for the reaction is shown.

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

Which volume of 0.4 mol/dm^3 sodium hydroxide reacts with 50.0 cm^3 of 0.1 mol/dm^3 sulfuric acid?

A 12.5 cm^3 **B** 25.0 cm^3 **C** 50.0 cm^3 **D** 100.0 cm^3

29. What is the relative molecular mass, M_r, of butanol?

A 15 **B** 37 **C** 74 **D** 148

30. The chemical formulae of two substances, W and X, are given.

W $NaAlSi_3O_8$

X $CaAl_2Si_2O_8$

Which statements are correct?

1 W and X contain the same amount of oxygen.

2 W contains three times as much silicon as X.

3 X contains twice as much aluminium as W.

A 1 and 2 **B** 1 and 3 **C** 2 and 3 **D** 1, 2 and 3

31. What is the concentration of a solution containing 1.0 g of sodium hydroxide in 250 cm^3 of solution?

$\frac{1.0}{40} = 0.025$ $\frac{0.025}{0.25} = 0.1$

A 0.025 mol / dm^3

B 0.10 mol / dm^3

C 0.25 mol / dm^3

D 1.0 mol / dm^3

$27 \times 2 + 16 \times 3 = 102$

32. Aluminium oxide has the formula Al_2O_3.

Which statement about aluminium oxide is correct?

A 2 g of aluminium atoms are combined with 3 g of oxygen atoms.

$2Al + 3O \rightarrow Al_2O_3$

$\frac{2 \times 27}{2} = \frac{3 \times 16}{x}$ $x = 1.78\,g$

B 2 g of aluminium atoms are combined with 3 g of oxygen molecules.

$4Al + 3O_2 \rightarrow 2Al_2O_3$

$\frac{4 \times 27}{2} = \frac{3 \times 32}{x}$ $x = 1.78\,g$

C Aluminium oxide has a relative molecular mass of 102.

D Pure aluminium oxide contains a higher mass of oxygen than of aluminium.

$27 \times 2 + 16 \times 3$

54 48

我觉得这题正确答案，但MS公布的选项.

33. **(a)** A compound, **X**, contains 55.85% carbon, 6.97% hydrogen and 37.18% oxygen.

(i) How does this prove that compound **X** contains only carbon, hydrogen and oxygen?

total percent is 100%

..... [1]

(ii) Use the above percentages to calculate the empirical formula of compound **X**.

$\frac{55.85}{12} : \frac{6.97}{1} : \frac{37.18}{16}$

$= 4.65 : 6.97 : 2.32 = 2 : 3 : 1$

C_2H_3O

..... [2]

(iii) The M_r of **X** is 86.

What is its molecular formula?

$C_2H_3O = 12\times2 + 3\times1 + 16 = 43$

$86 \div 43 = 2$

$C_4H_6O_2$

..... [2]

34. **(d)** Propanol reacts with methanoic acid to form the ester propyl methanoate.

$$CH_3CH_2CH_2OH + HCOOH \rightarrow HCOOCH_2CH_2CH_3 + H_2O$$

4.0 g of methanoic acid was reacted with 6.0 g of propanol.

(i) Calculate the M_r of methanoic acid = 46 [1]

(ii) Calculate the M_r of propanol = 60 [1]

(iii) Determine which one is the limiting reagent. Show your reasoning.

$n(HCOOH) = \frac{4.0}{46} = 0.0870\ mol$ $n(C_3H_7OH) = \frac{6.0}{60} = 0.1\ mol$

0.0870 mol of HCOOH required 0.0870 mol C_3H_7OH

∴ HCOOH is the limiting reagent.

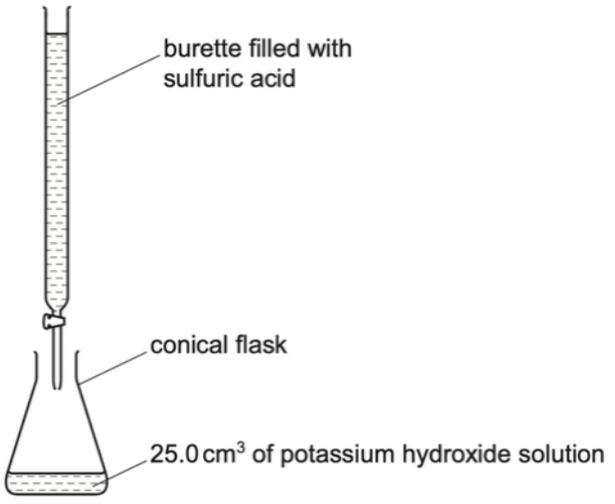
..... [2]

(iv) Calculate the maximum yield in grams of propyl methanoate, M_r = 88.

$0.0870 \times 88 = 7.656\ g$

..... [1]

35. Two salts can be made from potassium hydroxide and sulfuric acid. They are potassium sulfate, K_2SO_4, and the acid salt potassium hydrogen sulfate, $KHSO_4$. They are both made by titration.



(a) 25.0 cm^3 of potassium hydroxide, concentration 2.53 mol / dm^3, was neutralised by 28.2 cm^3 of dilute sulfuric acid.

$$2KOH(aq) + H_2SO_4(aq) \rightarrow K_2SO_4(aq) + 2H_2O(l)$$

Calculate the concentration of the sulfuric acid.

number of moles of KOH used = $0.0250 \times 2.53 = 0.06325$ mol

number of moles of H_2SO_4 needed to neutralise the KOH = 0.03163 mol

concentration of dilute sulfuric acid = $\frac{0.03163}{0.0282} = 1.12$ mol / dm^3

[3]

36. **(c)** The equation for the decomposition of copper(II) nitrate is given below.

$$2Cu(NO_3)_2 \rightarrow 2CuO + 4NO_2 + O_2$$

(ii) Copper(II) nitrate forms a series of hydrates with the formula $Cu(NO_3)_2.xH_2O$.
All these hydrates decompose to form copper(II) oxide.
1 mole of $Cu(NO_3)_2.xH_2O$ forms 1 mole of CuO.

What is meant by 1 mole of a substance?

one mole of a substance contain 6.02×10^{23} particles
(which means the number of C-12 atom in 12g of carbon-12) [2]

(iii) 7.26 g of a hydrate, $Cu(NO_3)_2.xH_2O$, formed 2.4 g copper(II) oxide.

number of moles of CuO formed = $\frac{2.4}{80} = 0.03$ mol

number of moles of $Cu(NO_3)_2.xH_2O$ in 7.26 g = 0.03 mol

mass of 1 mole of $Cu(NO_3)_2.xH_2O$ = $\frac{7.26}{0.03} = 242$ g

mass of 1 mole of $Cu(NO_3)_2$ is 188 g

the value of *x* in this hydrate = $\frac{242 - 188}{18} = 3$

[4]

37. Ethanol is manufactured from glucose, $C_6H_{12}O_6$, by fermentation according to the following equation.

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

(b) In an experiment, 30.0 g of glucose was fermented.

(i) Calculate the number of moles of glucose in 30.0 g.

$\frac{30.0}{180} = 0.167$ mol

.....0.167..... mol [2]

(ii) Calculate the maximum mass of ethanol that could be obtained from 30.0 g of glucose.

$n(C_2H_5OH) = 2 \times 0.167 = 0.333$ mol

$m = 0.333 \times 46 = 15.33$ g

.....15.33..... g [2]

(iii) Calculate the volume of carbon dioxide at room temperature and pressure that can be obtained from 30.0 g of glucose.

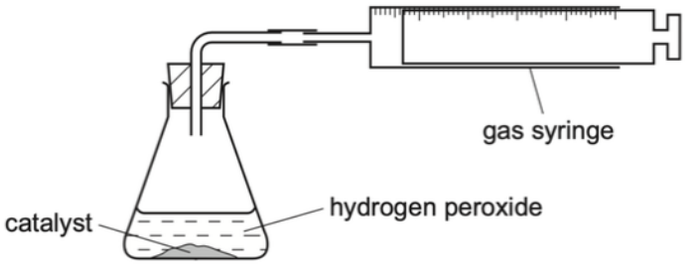
$n(CO_2) = 0.333$ mol

$V = 0.333 \times 24 = 7.92 dm^3$

.....7.92..... dm^3 [1]

38. A student studies the rate of decomposition of hydrogen peroxide using the apparatus shown. The student uses 20 cm^3 of 0.1 mol/dm^3 hydrogen peroxide and 1.0 g of manganese(IV) oxide.

The student measures the volume of oxygen given off at regular time intervals until the reaction stops. A graph of the results is shown.



(c) (i) Calculate the number of moles of hydrogen peroxide used in this experiment.

$0.1 \times 20 \times 10^{-3} =$

0.002 ..... mol [1]

(ii) Use your answer to **(c)(i)** and the equation to calculate the number of moles of oxygen produced in the reaction.

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

0.001 ..... mol [1]

(iii) Calculate the volume (at r.t.p.) of oxygen produced.

$0.001 \times 24 = 0.024$

0.024 ..... dm^3 [1]

(iv) What would be the effect on the volume of oxygen produced if the mass of catalyst was increased?

no effect ..... [1]

(v) Deduce the volume of oxygen that would be produced if 20 cm^3 of 0.2 mol/dm^3 hydrogen peroxide was used instead of 20 cm^3 of 0.1 mol/dm^3 hydrogen peroxide.

0.048 ..... dm^3 [1]

39. **(a)** Sodium nitrate is a white crystalline solid. When heated it melts and the following reaction occurs.

$$2NaNO_3(l) \rightarrow 2NaNO_2(l) + O_2(g)$$

A 3.40 g sample of sodium nitrate is heated.

Calculate the

- number of moles of $NaNO_3$ used,

$23+14+3\times16=85$

$\frac{3.40}{85} = 0.04$

0.04 ..... mol

- number of moles of O_2 formed,

0.02 ..... mol

- volume of O_2 formed, in dm^3 (measured at r.t.p.).

0.02×24

0.48 ..... dm^3

[3]

40. **(a)** Hydrocarbons are compounds which contain hydrogen and carbon only.

- 10 cm^3 of a gaseous hydrocarbon, C_xH_y, are burned in 100 cm^3 of oxygen, which is an excess of oxygen.
- After cooling to room temperature and pressure, there is 25 cm^3 of unreacted oxygen, 50 cm^3 of carbon dioxide and some liquid water.

All volumes are measured under the same conditions of temperature and pressure.

(i) What is meant by an *excess* of oxygen?

.....oxygen will be left after reaction..... [1]

(ii) What was the volume of oxygen that reacted with the hydrocarbon?

100 - 25 = 75

..... [1]

(iii) Complete the table below to express the smallest whole number ratio of

volume of hydrocarbon reacted : volume of oxygen reacted : volume of carbon dioxide produced

10 : 75 : 50

	volume of hydrocarbon reacted	volume of oxygen reacted	volume of carbon dioxide produced
smallest whole number ratio of volumes	2	15	10

[1]

(iv) Use your answer to **(a)(iii)** to find the mole ratio in the equation below. Complete the equation and deduce the formula of the hydrocarbon.

2 $C_xH_y(g)$ + 15 $O_2(g)$ → 10 $CO_2(g)$ + 10 $H_2O(l)$

5 10 30 20 10

formula of hydrocarbon = C_5H_{10}

[2]

41. Dilute hydrochloric acid reacts with sodium carbonate solution.

$$2HCl(aq) + Na_2CO_3(aq) \rightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$$

(a) Explain why effervescence is seen during the reaction.

A gas is produced.

[1]

(b) Dilute hydrochloric acid was titrated with sodium carbonate solution.

- 10.0 cm^3 of 0.100 mol/dm^3 hydrochloric acid were placed in a conical flask.
- A few drops of methyl orange indicator were added to the dilute hydrochloric acid.
- The mixture was titrated with sodium carbonate solution.
- 16.2 cm^3 of sodium carbonate solution were required to react completely with the acid.

(i) What colour would the methyl orange indicator be in the hydrochloric acid?

red [1]

(ii) Calculate how many moles of hydrochloric acid were used.

$10.0 \times 10^{-3} \times 0.100$

0.001 mol [1]

(iii) Use your answer to **(b)(ii)** and the equation for the reaction to calculate the number of moles of sodium carbonate that reacted.

0.0005 mol [1]

(iv) Use your answer to **(b)(iii)** to calculate the concentration of the sodium carbonate solution in mol/dm^3.

$$\frac{0.0005}{16.2 \times 10^{-3}}$$

0.0309 mol/dm^3 [2]

(c) In another experiment, 0.020 mol of sodium carbonate were reacted with excess hydrochloric acid.

Calculate the maximum volume (at r.t.p.) of carbon dioxide gas that could be made in this reaction.

$V = 0.020 \times 24 =$

0.48 dm^3 [3]

42. **(e)** Isoprene is a naturally occurring hydrocarbon.

(i) Explain how the name of isoprene suggests that it contains a C=C double bond.

ene represent "C=C"

..... [1]

(ii) A sample of isoprene had the following composition by mass: C, 88.24%; H, 11.76%.

Calculate the empirical formula of isoprene. Show all your working.

$\frac{88.24}{12} : 11.76$

$= 7.35 : 11.76 = 1 : 1.6 = 5 : 8$

empirical formula = C_5H_8 [3]

(iii) What additional information would be required to calculate the molecular formula of isoprene?

relative molecular mass

..... [1]

43. Chlorine, bromine and iodine are halogens.

(a) Chlorine can be made in the laboratory by heating manganese(IV) oxide with concentrated hydrochloric acid.

$$MnO_2(s) + 4HCl(aq) \rightarrow MnCl_2(aq) + 2H_2O(l) + Cl_2(g)$$

Calculate the volume of 8.00 mol / dm^3 $HCl(aq)$ needed to react with 3.48 g of MnO_2.

- moles of MnO_2 used

$\frac{3.48}{87}$

0.04 ..... mol

- moles of HCl needed

0.16 ..... mol

- volume of HCl needed

$\frac{0.16}{8} \times 10^3$

20 ..... cm^3

[4]

44. When lead(II) nitrate is heated, two gases are given off and solid lead(II) oxide remains.
The equation for the reaction is shown.

$$2Pb(NO_3)_2(s) \rightarrow 2PbO(s) + 4NO_2(g) + O_2(g)$$

(a) Calculate the M_r of lead(II) nitrate.

207 + (14+3×16) ×2 = 331

..... [1]

(b) 6.62 g of lead(II) nitrate are heated until there is no further change in mass.

(i) Calculate the mass of lead(II) oxide produced.

$\frac{6.62}{331} \times (207+16)$

4.46 g [2]

(ii) Calculate the volume of oxygen, O_2, produced at room temperature and pressure (r.t.p.).

$(\frac{6.62}{331} \div 2) \times 24 = 0.24$

0.24 dm^3 [2]

45. **(b) (i)** 5.95 g of cobalt(II) carbonate were added to 40 cm^3 of hydrochloric acid, concentration 2.0 mol/dm^3.

Calculate the maximum yield of cobalt(II) chloride-6-water and show that the cobalt(II) carbonate was in excess.

$$CoCO_3 + 2HCl \rightarrow CoCl_2 + CO_2 + H_2O$$

$$CoCl_2 + 6H_2O \rightarrow CoCl_2.6H_2O$$

maximum yield:

number of moles of HCl used = $2.0 \times 40 \times 10^{-3} = 0.008$ mol

number of moles of $CoCl_2$ formed = 0.004 mol

number of moles of $CoCl_2.6H_2O$ formed = 0.004 mol

mass of one mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = $0.004 \times 238 = 0.952$ g

to show that cobalt(II) carbonate is in excess:

number of moles of HCl used = 0.008 mol (use your value from above)

mass of one mole of $CoCO_3$ = 119 g

number of moles of $CoCO_3$ in 5.95 g of cobalt(II) carbonate = $\frac{5.95}{119} = 0.05$ mol [5]

(ii) Explain how these calculations show that cobalt(II) carbonate is in excess.

0.008 mol HCl required 0.004 mol $CoCl_2$ < 0.05 mol [1]

4b. Barium carbonate decomposes when heated.

$$BaCO_3(s) \rightarrow BaO(s) + CO_2(g)$$

(a) A student heated a 10.0 g sample of barium carbonate until it was fully decomposed.

(i) Calculate the number of moles of barium carbonate the student used.

$137 + 12 + 3 \times 16 = 197$

$\frac{10.0}{197} = 0.0508$ mol

moles of barium carbonate = ... 0.0508 ..... mol [2]

(ii) Calculate the volume of carbon dioxide gas produced at room temperature and pressure. Give your answer in dm^3.

0.0508×24

volume of carbon dioxide = ... 1.22 ..... dm^3 [1]

(b) The student added 2.00 g of the barium oxide produced to water.

$$BaO + H_2O \rightarrow Ba(OH)_2$$

Calculate the mass of barium hydroxide that can be made from 2.00 g of barium oxide. The M_r of $Ba(OH)_2$ is 171.

$\frac{2.00}{137+16} \times 171 =$

mass of barium hydroxide = ... 2.24 ..... g [1]

(c) A 1.50 g sample of barium hydroxide was dissolved in water. The total volume of the solution was 100 cm^3.

A 25.0 cm^3 portion of the barium hydroxide solution was titrated against hydrochloric acid. The volume of hydrochloric acid required was 18.75 cm^3.

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

(i) Calculate how many moles of barium hydroxide were in the 25.0 cm^3 portion used in the titration.

$\frac{1.50}{171} \times \frac{1}{4} =$

moles of barium hydroxide = ... 0.0022 ..... mol [1]

(ii) Calculate the concentration of the hydrochloric acid used.

$\frac{0.0022 \times 2}{18.75 \times 10^{-3}}$

concentration of hydrochloric acid = ... 0.234 ..... mol/dm^3 [2]

47. **(b)** Magnesium sulfate crystals are hydrated. Another student heated some hydrated magnesium sulfate crystals in a crucible and obtained the following results.

mass of hydrated magnesium sulfate crystals = 4.92 g

mass of water removed = 2.52 g

(i) Calculate the number of moles of water removed.

$\frac{2.52}{18}$ =

moles of water = 0.14 mol [1]

(ii) Calculate the number of moles of anhydrous magnesium sulfate remaining in the crucible. The M_r of anhydrous magnesium sulfate is 120.

$\frac{4.92 - 2.52}{120}$ =

moles of anhydrous magnesium sulfate = 0.02 mol [1]

(iii) Calculate the ratio of moles of anhydrous magnesium sulfate : moles of water. Give your answer as whole numbers.

ratio = 1 : 7 [1]

(iv) Suggest the formula of hydrated magnesium sulfate crystals.

formula of hydrated magnesium sulfate crystals = $MgSO_4 \cdot 7H_2O$ [2]

48. A sample of vanadium chloride was weighed and dissolved in water. An excess of aqueous silver nitrate, acidified with dilute nitric acid, was added. A precipitate of silver chloride was formed. The ionic equation for this reaction is shown.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The mass of silver chloride formed was 2.87 g.

(i) State the colour of the precipitate of silver chloride.

.....White..... [1]

(ii) The relative formula mass of silver chloride, AgCl, is 143.5.

Calculate the number of moles in 2.87 g of AgCl.

$$\frac{2.87}{143.5}$$

moles of AgCl = ...0.02..... mol [1]

(iii) Use your answer to **(b)(ii)** and the ionic equation to deduce the number of moles of chloride ions, Cl^-, that produced 2.87 g of AgCl.

moles of Cl^- = ...0.02..... mol [1]

(iv) The amount of vanadium chloride in the sample was 0.01 moles.

Use this and your answer to **(b)(iii)** to deduce the **whole number** ratio of moles of vanadium chloride : moles of chloride ions.
Deduce the formula of vanadium chloride.

moles of vanadium chloride : moles of chloride ions .....1..... : .....2.....

formula of vanadium chloride .....VCl_2.....
[2]

49. Barium carbonate reacts with dilute hydrochloric acid.

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

9.85 g of barium carbonate were added to 250 cm^3 of 1.00 mol/dm^3 hydrochloric acid. This is an excess of hydrochloric acid.

(i) Calculate how many moles of barium carbonate were used in this experiment.

$\frac{9.85}{137+12+3\times16} = \frac{9.85}{187} = 0.0527$ mol

moles of barium carbonate = 0.0527 mol [2]

(ii) Deduce how many moles of carbon dioxide were made when all the barium carbonate had reacted.

moles of carbon dioxide = 0.0527 mol [1]

(iii) Calculate the volume of carbon dioxide formed in **(c)(ii)** at room temperature and pressure, in dm^3.

$0.0527 \times 24 =$

volume of carbon dioxide = 1.26 dm^3 [1]

(iv) Calculate how many moles of hydrochloric acid there were **in excess**.

total = $0.25 \times 1.00 = 0.25$ mol

react = $0.0527 \times 2 = 0.1054$ mol

excess = $0.25 - 0.1054 = 0.1446$

excess moles of hydrochloric acid = 0.1446 mol [2]

50. Hydrogen can be manufactured using a reversible reaction between methane and steam.

$$CH_4(g) + H_2O(g) \rightleftharpoons CO(g) + 3H_2(g)$$

At 900 °C, in the presence of a nickel catalyst, the yield of hydrogen is 70%.

(i) What volume of hydrogen is produced from 100 cm^3 of methane under these conditions?

100×3× 70%

..... 210 ..... cm^3 [2]

Under different conditions, different yields of hydrogen are obtained.

(ii) If the pressure is increased, the yield of hydrogen becomes less than 70%.

Explain why, in terms of the position of the equilibrium.

..... less gaseous particles in left side .....

..... [1]

(iii) If the temperature is decreased, the yield of hydrogen decreases.

What does this information indicate about the reaction between methane and steam?

..... forward reaction is endothermic ..... [1]

(iv) Why is a catalyst used in this reaction?

..... speed up the reaction ..... [1]

51. **(b)** 25 cm^3 of a gaseous hydrocarbon, C_xH_y, were burnt in 150 cm^3 of oxygen. This was an excess of oxygen.

After cooling, the volume of the gases remaining was 100 cm^3. This consisted of 75 cm^3 of carbon dioxide and 25 cm^3 of unreacted oxygen. The water that was produced in the reaction was liquid.

All volumes were measured at the same temperature and pressure.

(i) What is meant by an *excess* of oxygen?

Oxygen will be left after reaction. [1]

(ii) What was the volume of oxygen that reacted with the hydrocarbon?

125 cm^3 [1]

(iii) Complete the table to show the smallest whole number ratio of volumes.

	volume of hydrocarbon reacted	:	volume of oxygen reacted	:	volume of carbon dioxide produced
	25		125		75
smallest whole number ratio of volumes	1	:	5	:	3

[1]

(iv) Use your answer to **(b)(iii)** to balance the chemical equation. Deduce the formula of the hydrocarbon.

$C_xH_y(g)$ + 5 $O_2(g)$ → 3 $CO_2(g)$ + 4 $H_2O(l)$

formula of the hydrocarbon = C_3H_8 [2]