Q1 A pure hydrocarbon is used in bottled gas for cooking and heating.
When 10 cm^3 of the hydrocarbon is burned in 70 cm^3 of oxygen (an excess), the final gaseous mixture contains 30 cm^3 of carbon dioxide and 20 cm^3 of unreacted oxygen. All gaseous volumes were measured under identical conditions.
What is the formula of the hydrocarbon?
A C_2H_6 B C_3H_6 C C_3H_8 D C_4H_{10}

Q2 On collision, airbags in cars inflate rapidly due to the production of nitrogen.
The nitrogen is formed according to the following equations.

$$2NaN_3 \rightarrow 2Na + 3N_2$$

$$10Na + 2KNO_3 \rightarrow K_2O + 5Na_2O + N_2$$

How many moles of nitrogen gas are produced from 1 mol of sodium azide, NaN_3?
A 1.5 B 1.6 C 3.2 D 4.0

Q3 N_2O_4 is a poisonous gas. It can be disposed of safely by reaction with sodium hydroxide.

$$N_2O_4(g) + 2NaOH(aq) \rightarrow NaNO_3(aq) + NaNO_2(aq) + H_2O(l)$$

What is the minimum volume of 0.5 mol dm^{-3} NaOH(aq) needed to dispose of 0.02 mol of N_2O_4?
A 8 cm^3 B 12.5 cm^3 C 40 cm^3 D 80 cm^3

Q4 Oxides of nitrogen are pollutant gases which are emitted from car exhausts.
In urban traffic, when a car travels one kilometre, it releases 0.23 g of an oxide of nitrogen N_xO_y, which occupies 120 cm^3. What are the values of x and y?
(Assume 1 mol of gas molecules occupies 24.0 dm^3.)
A x = 1, y = 1 B x = 1, y = 2
C x = 2, y = 1 D x = 2, y = 4

Q5 In the Basic Oxygen steel-making process the P_4O_{10} impurity is removed by reacting it with calcium oxide. The only product of this reaction is the salt calcium phosphate, $Ca_3(PO_4)_2$. In this reaction, how many moles of calcium oxide react with one mole of P_4O_{10}?
A 1 B 1.5 C 3 D 6

Q6 A typical solid fertiliser for use with household plants and shrubs contains the elements N, P, and K in the ratio of 15 g : 30 g :15 g per 100 g of fertiliser. The recommended usage of fertiliser is 14 g of fertiliser per 5 dm^3 of water.
What is the concentration of nitrogen atoms in this solution?
A 0.03 mol dm^{-3} B 0.05 mol dm^{-3}
C 0.42 mol dm^{-3} D 0.75 mol dm^{-3}

Q7 In leaded petrol there is an additive composed of lead, carbon and hydrogen only. This compound contains 29.7 % carbon and 6.19 % hydrogen by mass.
What is the value of x in the empirical formula PbC_8H_x?
A 5 B 6 C 16 D 20

Q8 A household bleach contains sodium chlorate(I), NaClO, as its active ingredient. The concentration of NaClO in the bleach can be determined by reacting a known amount with aqueous hydrogen peroxide, H_2O_2.

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

When 25.0 cm^3 of bleach is treated with an excess of aqueous H_2O_2, 0.0350 mol of oxygen gas is given off. What is the concentration of NaClO in the bleach?
A 8.75×10^{-4} mol dm^{-3} B 0.700 mol dm^{-3}
C 0.875 mol dm^{-3} D 1.40 mol dm^{-3}

Q9 Which mass of gas would occupy a volume of 3 dm^3 at 25 °C and 1 atmosphere pressure? [1 mol of gas occupies 24 dm^3 at 25 °C and 1 atmosphere pressure.]

A 3.2 g O_2 gas
B 5.6 g N_2 gas
C 8.0 g SO_2 gas
D 11.0 g CO_2 gas

Q10 2.920 g of a Group II metal, X, reacts with an excess of chlorine to form 5.287 g of a compound with formula XCl_2.
What is metal X?

A barium B calcium C magnesium D strontium

Q11 Tanzanite is used as a gemstone for jewellery. It is a hydrated calcium aluminium silicate mineral with a chemical formula $Ca_2Al_xSi_yO_{12}(OH).6.H_2O$. Tanzanite has M_r of 571.5. Its chemical composition is 14.04 % calcium, 14.17 % aluminium, 14.75 % silicon, 54.59 % oxygen and 2.45 % hydrogen. (A_r values: H = 1.0, O = 16.0, Al = 27.0, Si = 28.1, Ca = 40.1)
What are the values of x and y?

	x	y
A	1	1
B	2	3
C	3	3
D	6	1

Q12 0.144 g of an aluminium compound X react with an excess of water, to produce a gas. This gas burns completely in O_2 to form H_2O and 72 cm^3 of CO_2 only. The volume of CO_2 was measured at room temperature and pressure. What could be the formula of X?
[C = 12.0, Al = 27.0; 1 mole of any gas occupies 24 dm^3 at room temperature and pressure]

A Al_2C_3 B Al_3C_4 C Al_4C_3 D Al_5C_3

Q13 The petrol additive tetraethyl-lead(IV), $Pb(C_2H_5)_4$, is now banned in many countries. When it is completely burned in air, lead(II) oxide, CO_2 and H_2O are formed.
How many moles of oxygen are required to burn one mole of $Pb(C_2H_5)_4$?

A 9.5 B 11 C 13.5 D 27

Q14 When a sports medal with a total surface area of 150 cm^2 was evenly coated with silver, using electrolysis, its mass increased by 0.216 g.
How many atoms of silver were deposited per cm^2 on the surface of the medal?

A 8.0×10^{18}
B 1.8×10^{19}
C 1.2×10^{21}
D 4.1×10^{22}

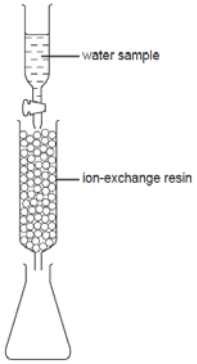
Q15 The first stage in the manufacture of nitric acid is the oxidation of ammonia by oxygen.

$$wNH_3(g) + xO_2(g) \rightarrow yNO(g) + zH_2O(g)$$

Which values for w, x, y and z are needed to balance the equation?

	w	x	y	z
A	4	5	4	6
B	4	6	4	5
C	5	6	5	4
D	6	5	6	4

Q16 The amount of calcium ions in a sample of natural water can be determined by using an ion exchange column as shown in the diagram.



A 50 cm^3 sample of water containing dissolved calcium sulphate was passed through the ionexchange resin. Each calcium ion in the sample was exchanged for two hydrogen ions. The resulting acidic solution collected in the flask required 25 cm^3 of 1.0×10^{-2} mol dm^{-3} potassium hydroxide for complete neutralisation.
What was the concentration of the calcium sulphate in the original sample?

A 2.5×10^{-3} mol dm^{-3}

B 1.0×10^{-2} mol dm^{-3}

C 2.0×10^{-2} mol dm^{-3}

D 4.0×10^{-2} mol dm^{-3}

Q17 Titanium(IV) oxide, TiO_2, is brilliantly white and much of the oxide produced is used in the manufacture of paint. What is the maximum amount of TiO_2 obtainable from 19.0 tonnes of the ore ilmenite, $FeTiO_3$?
A 10.0 tonnes B 12.7 tonnes C 14.0 tonnes D 17.7 tonnes

Q18 Carbon disulphide vapour burns in oxygen according to the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

A sample of 10 cm^3 of carbon disulphide was burned in 50 cm^3 of oxygen. After measuring the volume of gas remaining, the product was treated with an excess of aqueous sodium hydroxide and the volume of gas measured again. All measurements were made at the same temperature and pressure, under such conditions that carbon disulphide was gaseous.
What were the measured volumes?

	volume of gas after burning / cm^3	volume of gas after adding NaOH(aq) / cm^3
A	30	0
B	30	20
C	50	20
D	50	40

Q19 0.200 mol of a hydrocarbon undergo complete combustion to give 35.2 g of carbon dioxide and 14.4 g of water as the only products.
What is the molecular formula of the hydrocarbon?
A C_2H_4 B C_2H_6 C C_4H_4 D C_4H_8

Q20 The following equations the letters W, X, Y and Z all represent whole numbers.
When correctly balanced, which equation requires one of letters W, X, Y or Z to be 5?
A $WC_3H_7COOH + XO_2 \rightarrow YCO_2 + ZH_2O$
B $WC_4H_8 + XO_2 \rightarrow YCO_2 + ZH_2O$
C $WH_3PO_4 + XNaOH \rightarrow YNa_2HPO_4 + ZH_2O$
D $WNH_3 + XO_2 \rightarrow YN_2 + ZH_2O$

1. C
2. B
3. D
4. B
5. D
6. A
7. D
8. D
9. C
10. D
11. C
12. C
13. C
14. A
15. A
16. A
17. A
18. C
19. D
20. A

Q1 A sample of iron has the following isotopic composition by mass.

isotope mass	54	56	57
% by mass	5.84	91.68	2.17

(i) Define the term relative atomic mass.

.....

.....

.....

(ii) By using the data above, calculate the relative atomic mass of iron to **three** significant figures.

(June 2005)

Q2 **W** has the following composition by mass: C, 40.0%; H, 6.7%; O, 53.3%. Use this information and the Data Booklet to show that the empirical formula of **W** is CH_2O.

(June 2007)

Q3 **W** has the following composition by mass: C, 35.8%; H, 4.5%; O, 59.7%. Show by calculation that the empirical formula of **W** is $C_4H_6O_5$.

The M_r of **W** is 134. Use this value to determine the molecular formula of **W**.

(June 2010 P21)

Q4 An organic compound, **E**, has the following composition by mass: C, 48.7%; H, 8.1%; O, 43.2%. Calculate the empirical formula of **E**.

(June 2010 P22)

Q5 In a redox reaction, 0.83 g of lithium reacted with water to form 0.50 dm^3 of aqueous lithium hydroxide.

$$2Li(s) + 2H_2O(l) \longrightarrow 2LiOH(aq) + H_2(g)$$

(i) Calculate the amount, in moles, of lithium that reacted.

(ii) Calculate the volume of hydrogen produced at room temperature and pressure.

(iii) Calculate the concentration, in mol dm^{-3}, of the LiOH(aq) formed.

(June 2010 P23)

Q6 The flight path from Beijing to Paris is approximately 8195 km. A typical intercontinental jet airliner burns 10.8 kg of kerosene for each kilometre covered.

(i) Calculate the mass, in tonnes, of $C_{14}H_{30}$ burnt on a flight from Beijing to Paris.

(ii) Calculate the mass, in tonnes, of CO_2 produced during this flight.

(June 2011 P21)

Q7 When we are stung by a 'typical' ant a solution of methanoic acid, **A**, is injected into our skin. Solution **A** contains 50% by volume of pure methanoic acid.
A 'typical' ant contains 7.5×10^{-6} dm^3 of solution **A**.

(a)(i) Calculate the volume, in cm^3, of solution **A** in one ant.

(**ii**) Use your answer to **(i)** to calculate the volume, in cm^3, of pure methanoic acid in one ant.

(**iii)** Use your answer to **(ii)** to calculate how many ants would have to be distilled to produce 1 dm^3 of methanoic acid.

When we are stung by an ant, the amount of solution **A** injected is 80% of the total amount of solution **A** present in one ant.

The density of pure methanoic acid is $1.2\,g\,cm^{-3}$.

(b)(i) Calculate the volume, in cm^3, of **pure** methanoic acid injected in one ant sting.

(ii) Use your answer to **(i)** to calculate the mass of methanoic acid present in one ant sting.

Bees also sting us by using methanoic acid. One simple treatment for ant or bee stings is to use sodium hydrogencarbonate, $NaHCO_3$.

(c)(i) Construct a balanced equation for the reaction between methanoic acid and sodium hydrogencarbonate.

.....

(ii) In a typical bee sting, the mass of methanoic acid injected is 5.4×10^{-3} g.
Calculate the mass of $NaHCO_3$ needed to neutralise one bee sting.

(June 2011 P23)

Q8 The food additive E330 is another organic compound which occurs naturally in fruit. E330 has the following composition by mass: C, 37.5 %; H, 4.17 %; O, 58.3 %.
Calculate the empirical formula of E330.

(JUNE 2012 P22)

Q9 Ammonium sulfate, $(NH_4)_2SO_4$, is widely used as a fertiliser. In order to determine its percentage purity, a sample of ammonium sulfate fertiliser was analysed by reacting a known amount with an excess of NaOH(aq) and then titrating the unreacted NaOH with dilute HCl.

(**a**) Ammonium sulfate reacts with NaOH in 1:2ratio.
Complete and balance the equation for this reaction.

$(NH_4)_2SO_4 + 2NaOH \rightarrow$ .....NH_3 + ... + ...

(b) A 5.00 g sample of a fertiliser containing $(NH_4)_2SO_4$ was warmed with 50.0 cm^3 (an excess) of 2.00 mol dm^{-3} NaOH. When all of the ammonia had been driven off, the solution was cooled. The remaining NaOH was then titrated with 1.00 mol dm^{-3} HCl and 31.2 cm^3 were required for neutralisation.

(i) Write a balanced equation for the reaction between NaOH and HCl.

.....

(ii) Calculate the amount, in moles, of HCl in 31.2 cm^3 of 1.00 mol dm^{-3} HCl.

(iii) Calculate the amount, in moles, of NaOH in 50.0 cm^3 of 2.00 mol dm^{-3} NaOH.

(iv) Use your answers to **(i)**, **(ii)** and **(iii)** to calculate the amount, in moles, of NaOH used up in the reaction with $(NH_4)_2SO_4$.

(v) Use your answer to **(iv)** and the equation in **(a)** to calculate the amount, in moles, of $(NH_4)_2SO_4$ that reacted with NaOH.

(vi) Use your answer to **(v)** to calculate the mass of $(NH_4)_2SO_4$ that reacted with NaOH.

(vii) Hence, calculate the percentage purity of the ammonium sulfate fertiliser.

(JUNE 2012 P21)

Q10 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$. A student wished to determine the value of x by carrying out a titration, with the following results.

> 5.13 g of washing soda crystals were dissolved in water and the solution was made up to 250 cm^3 in a standard volumetric flask.
>
> 25.0 cm^3 of this solution reacted exactly with 35.8 cm^3 of 0.100 mol dm^{-3} hydrochloric acid and carbon dioxide was produced.

(a)(i) Write a balanced equation for the reaction between Na_2CO_3 and HCl.

.....

(ii) Calculate the amount, in moles, of HCl in the 35.8 cm^3 of solution used in the titration.

(iii) Use your answers to **(i)** and **(ii)** to calculate the amount, in moles, of Na_2CO_3 in the 25.0 cm^3 of solution used in the titration.

(iv) Use your answer to **(iii)** to calculate the amount, in moles, of Na_2CO_3 in the 250 cm^3 of solution in the standard volumetric flask.

(v) Hence calculate the mass of Na_2CO_3 present in 5.13 g of washing soda crystals.

(b) Use your calculations in **(a)** to determine the value of x in $Na_2CO_3.xH_2O$.

(JUNE 2012 P23)

Q11 Calculate the volume of CO_2, in dm^3, measured at room temperature and pressure, which will be formed when 3.5 g of ketene (C_2H_2O) are burned in an excess of air.

(NOV 2008)

Q12 (**a**) Construct a balanced equation for the decomposition of H_2O_2.

.....

Hydrocarbon $C_{15}H_{32}$ reacts completely with oxygen according to the following equation.

$$C_{15}H_{32} + 23O_2 \rightarrow 15CO_2 + 16H_2O$$

(**b**) Use the equation above and your answer to **(a)** to calculate the amount, in moles, of H_2O_2, that will provide sufficient oxygen for the complete oxidation of one mole of $C_{15}H_{32}$.

A submarine equipped with a Walter engine used 212 tonnes of diesel fuel during an underwater voyage. The submarine also carried concentrated aqueous H_2O_2.

[1 tonne = 10^6 g]

(**c**) Calculate the amount, in moles, of diesel fuel used during the underwater voyage.

(**d**) Use your answers to **(b)** and **(c)** to calculate the mass, in tonnes, of hydrogen peroxide used during the underwater voyage.

(NOV 2008)

Q13 (a) Explain the meaning of the term isotope.

.....

.....

.....

A sample of magnesium has the following isotopic composition by mass.

isotope mass	24	25	26
% by mass	78.60	10.11	11.29

(b) Calculate the relative atomic mass, A_r, of magnesium to **four** significant figures.

(NOV 2009 P21)

Q14 In 1814, Sir Humphrey Davy and Michael Faraday collected samples of a flammable gas,**A**, from the ground near Florence in Italy.They analysed **A** which they found to be a hydrocarbon. Further experiments were then carried out to determine the molecular formula of **A**.

(a) What is meant by the term molecular formula?

.....

.....

(b) Complete and balance the following equation for the complete combustion of a hydrocarbon with the formula C_xH_y.

$$C_xH_y + \left(x + \frac{y}{4}\right)O_2 \rightarrow \text{.....} + \text{.....}$$

(c) When 10 cm^3 of **A** was mixed at room temperature with 50 cm^3 of oxygen (an excess) and exploded, 40 cm^3 of gas remained after cooling the apparatus to room temperature and pressure. When this 40 cm^3 of gas was shaken with an excess of aqueous potassium hydroxide, KOH, 30 cm^3 of gas still remained.

(i) What is the identity of the 30 cm^3 of gas that remained at the end of the experiment?

.....

(ii) The combustion of **A** produced a gas that reacted with the KOH(aq).What is the identity of this gas?

.....

(iii) What volume of the gas you have identified in **(ii)** was produced by the combustion of **A**?

.....cm^3

(iv) What volume of oxygen was used up in the combustion of **A**?

.....cm^3

(d) Use your equation in **(b)** and your results from **(c)(iii)** and **(c)(iv)** to calculate the molecular formula of **A**.

(NOV 2010 P21)

Q15 Compound **A** is an organic compound which contains carbon, hydrogen and oxygen. When 0.240 g of the vapour of **A** is slowly passed over a large quantity of heated copper(II) oxide, CuO, the organic compound **A** is completely oxidised to carbon dioxide and water. Copper is the only other product of the reaction. The products are collected and it is found that 0.352 g of CO_2 and 0.144 g of H_2O are formed.

(a)(i) Calculate the mass of carbon present in 0.352 g of CO_2.

Use this value to calculate the amount, in moles, of carbon atoms present in 0.240 g of **A**.

(ii) Calculate the mass of hydrogen present in 0.144 g of H_2O.

Use this value to calculate the amount, in moles, of hydrogen atoms present in 0.240 g of **A**.

(iii) Use your answers to calculate the mass of oxygen present in 0.240 g of **A**.

Use this value to calculate the amount, in moles, of oxygen atoms present in 0.240 g of **A**.

(b) Use your answers to **(a)** to calculate the empirical formula of **A**.

(NOV 2011 P21)

Q16 A simple experiment to determine the value of *x* in the formula $ZnSO_4.xH_2O$ is to heat it carefully to drive off the water.

$$ZnSO_4.xH_2O(s) \rightarrow ZnSO_4(s) + xH_2O(g)$$

(a)A student placed a sample of the hydrated zinc sulfate in a weighed boiling tube and reweighed it. He then heated the tube for a short time, cooled it and reweighed it when cool. This process was repeated four times. The final results are shown below.

(i) Calculate the amount, **in moles**, of the anhydrous salt produced.

(ii) Calculate the amount, **in moles**, of water driven off by heating.

(iii) Use your results to **(i)** and **(ii)** to calculate the value of x in $ZnSO_4.xH_2O$.

(b) For many people, an intake of approximately 15 mg per day of zinc will be sufficient to prevent deficiencies.
Zinc ethanoate crystals, $(CH_3CO_2)_2Zn.2H_2O$, may be used in this way.
(i) What mass of pure crystalline zinc ethanoate (M_r = 219.4) will need to be taken to obtain a dose of 15 mg of zinc?

(ii) If this dose is taken in solution as 5 cm^3 of aqueous zinc ethanoate, what would be the concentration of the solution used?
Give your answer in mol dm^{-3}.

(Nov 2012 P22)

Q17 Carbon dioxide, CO_2, makes up about 0.040 % of the Earth's atmosphere. It is produced by animal respiration and by the combustion of fossil fuels.
In animal respiration, oxygen reacts with a carbohydrate such as glucose to give water, carbon dioxide and energy.
The typical daily food requirement of a human can be considered to be the equivalent of 1.20 kg of glucose, $C_6H_{12}O_6$.
You should express all of your numerical answers in this question to three significant figures.
(a) (i) Construct a balanced equation for the complete oxidation of glucose.

……
(ii) Use your equation to calculate the amount, in moles, of CO_2 produced by one person in one day from 1.20 kg of glucose.

(iii) On the day on which this question was written, the World population was estimated to be 6.82×10^9.
Calculate the total mass of CO_2 produced by this number of people in one day. Give your answer in tonnes. [1 tonne = 1.00×10^6 g]

(b) When fossil fuels are burned in order to give energy, carbon dioxide and water are also produced.
The hydrocarbon octane, C_8H_{18}, can be used to represent the fuel burned in motor cars.
A typical fuel-effi cient motor car uses about 4.00 dm^3 of fuel to travel 100 km.
(i) Construct a balanced equation for the complete combustion of octane.

……

(ii) The density of octane is 0.700 g cm^{-3}.
Calculate the amount, in moles, of octane present in 4.00 dm^3 of octane.

(iii) Calculate the mass of CO_2 produced when the fuel-efficient car is driven for a distance of 100 km.

(c) Calculate how many kilometres the same fuel-effi cient car would have to travel in order to produce as much CO_2 as is produced by the respiration of 6.82×10^9 people during one day. Use your answer to **(a)(iii)**.

(Nov 2012 P23)