MOLES & STOICHIOMETRY (iGCSE)

Fahad H. Ahmad
www.fahadsacademy.com
+92 323 509 4443

IGCSE 0620 – Multiple Choice Questions

Question 1

35 A label on a bottle of spring water gives the following information.

Contents per litre	
Calcium	25.0 mg
Magnesium	4.5 mg
Potassium	1.0 mg
Sodium	6.5 mg
Hydrogencarbonate	103 mg
Sulphate	10.5 mg
Nitrate	7.0 mg
Chloride	5.5 mg

What is the total mass of singly charged positive ions in the water?

A 7.5 mg **B** 12.5 mg **C** 29.5 mg **D** 115.5 mg

0620_w/07/qp1

Question 2

10 The diagram shows a model of a molecule of an organic acid.

What is the relative molecular mass of this acid?

A 11 **B** 40 **C** 58 **D** 74

0620_w/07/qp1

Question 3

9 The equation shows the reaction that occurs when ethanol burns in air.

$$C_2H_5OH + x\,O_2 \longrightarrow y\,CO_2 + z\,H_2O$$

Which values of x, y and z are needed to balance this equation?

	x	y	z
A	2	2	2
B	2	2	3
C	2	3	3
D	3	2	3

0620_w/05/qp1

Question 4

10 Which formula represents a compound containing three atoms?

A HNO_3 **B** H_2O **C** LiF **D** $ZnSO_4$

0620_w/04/qp1

Question 5

9 When propane is burned, carbon dioxide and water are formed, as shown.

$$C_3H_8 + 5O_2 \rightarrow r\,CO_2 + s\,H_2O$$

Which values of *r* and *s* balance the equation?

	r	*s*
A	1	3
B	1	5
C	3	4
D	3	8

0620_w/04/qp1

Question 6

10 Two gases react as shown.

$$\underset{\text{reactants}}{X_2 + Y_2} \rightarrow \underset{\text{product}}{2XY}$$

When measured at the same temperature and pressure, what is the value of

$$\frac{\text{volume of product}}{\text{volume of reactants}} ?$$

A $\frac{1}{2}$

B 1

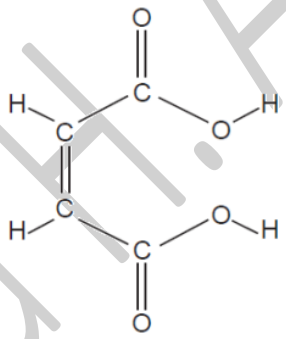
C 2

D 4

0620_w/03/qp1

Question 7

11 Butenedioic acid has the structure shown.



What is the molecular formula of butenedioic acid?

A CHO **B** $C_4H_4O_4$ **C** $C_6H_4O_2$ **D** $C_6H_4O_6$

0620_w/02/qp1

Question 8

9 One method of producing carbon dioxide is to react calcium carbonate with dilute hydrochloric acid.

What is the balanced chemical equation for the reaction?

A $CaCO_3 + HCl \longrightarrow CaO + CO_2 + HCl$

B $CaCO_3 + 2HCl \longrightarrow CaCl_2 + CO_2 + H_2O$

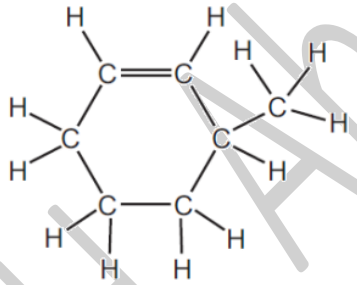
C $CaCO_3 + 4HCl \longrightarrow CaCl_4 + CO_2 + H_2 + H_2O$

D $Ca(HCO_3)_2 + HCl \longrightarrow CaCl + 2CO_2 + H_2O$

0620_w/02/qp1

Question 9

8 The structure of an organic compound, X, is shown.



What is the molecular formula of X?

A C_6H_9 **B** C_6H_{12} **C** C_7H_{12} **D** C_7H_{14}

0620_s/14/qp12

Question 10

9 What is the relative molecular mass, M_r, of nitrogen dioxide?

A 15 **B** 23 **C** 30 **D** 46

0620_s/14/qp12

Question 11

10 In athletics, banned drugs such as nandrolone have been taken illegally to improve performance. Nandrolone has the molecular formula $C_{18}H_{26}O_2$.

What is the relative molecular mass, M_r, of nandrolone?

(Relative atomic mass: H = 1; C = 12; O = 16)

A 46 **B** 150 **C** 274 **D** 306

0620_s/14/qp11

Question 12

9 A compound with the formula XF_2 has a relative formula mass of 78.

What is element X?

A argon

B calcium

C neon

D zirconium

0620_s/13/qp11

Question 13

10 What is the balanced chemical equation for the reaction between calcium and water?

A $Ca + H_2O \rightarrow CaOH + H_2$

B $Ca + H_2O \rightarrow Ca(OH)_2 + H_2$

C $Ca + 2H_2O \rightarrow CaOH + H_2$

D $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$

0620_s/13/qp12

Question 14

7 The equation shows the reaction between magnesium and sulfuric acid.

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

(Mg = 24, H = 1, S = 32, O = 16)

In this reaction, what mass of magnesium sulfate will be formed when 6 g of magnesium reacts with excess sulfuric acid?

A 8 **B** 24 **C** 30 **D** 60

0620_s/13/qp12

Question 15

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

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

M_r of $MgSO_4$ is 120

Which mass of magnesium sulfate will be formed if 12 g of magnesium are reacted with sulfuric acid?

A 5 g **B** 10 g **C** 60 g **D** 120 g

0620_s/12/qp11

Question 16

8 What is the relative molecular mass (M_r) of HNO_3?

A 5 **B** 31 **C** 32 **D** 63

0620_s/11/qp11

Question 17

10 Hydrogen and chlorine react as shown.

1 molecule of hydrogen + 1 molecule of chlorine → 2 molecules of hydrogen chloride

What is the equation for this reaction?

A $2H + 2Cl \rightarrow 2HCl$

B $2H + 2Cl \rightarrow H_2Cl_2$

C $H_2 + Cl_2 \rightarrow 2HCl$

D $H_2 + Cl_2 \rightarrow H_2Cl_2$

0620_s/10/qp11

Question 18

10 Nitrogen and hydrogen react together to form ammonia.

$$N_2 + 3H_2 \rightarrow 2NH_3$$

When completely converted, 7 tonnes of nitrogen gives 8.5 tonnes of ammonia.

How much nitrogen will be needed to produce 34 tonnes of ammonia?

A 7 tonnes **B** 8.5 tonnes **C** 28 tonnes **D** 34 tonnes

0620_s/09/qp11

Question 19

11 Which relative molecular mass, M_r, is **not** correct for the molecule given?

	molecule	M_r
A	ammonia, NH_3	17
B	carbon dioxide, CO_2	44
C	methane, CH_4	16
D	oxygen, O_2	16

0620_s/09/qp11

Question 20

11 Students are asked to state

- the number of atoms in one molecule of ethanoic acid,
- the relative molecular mass, M_r, of this acid.

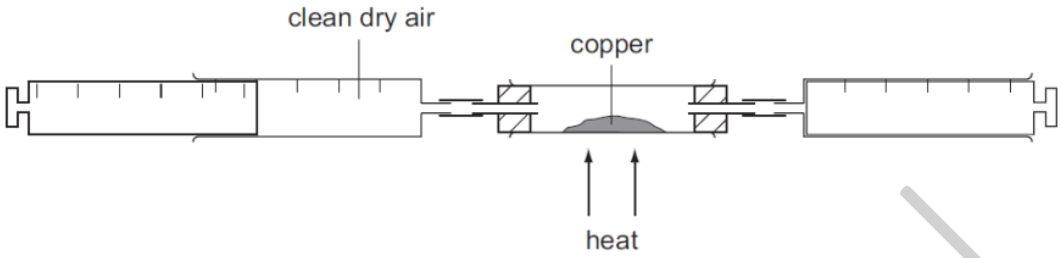
Which line is correct?

	number of atoms	M_r
A	8	32
B	8	60
C	9	26
D	9	46

0620_s/07/qp1

Question 21

29 A sample of clean, dry air is passed over hot copper until **all** the oxygen in the air reacts with the copper.



The volume of air decreases by 30 cm^3.

What was the starting volume of the sample of air?

A 60 cm^3 **B** 100 cm^3 **C** 150 cm^3 **D** 300 cm^3

0620_s/04/qp1

Question 22

10 The compound ethyl mercaptan, C_2H_5SH, has a very unpleasant smell.

What is its relative molecular mass?

A 34 **B** 50 **C** 61 **D** 62

0620_s/04/qp1

Question 23

11 Water is formed when 48 g of oxygen combine with 6 g of hydrogen.

What mass of oxygen combines with 2 g of hydrogen?

A 12 g **B** 16 g **C** 96 g **D** 144 g

0620_s/03/qp1

Question 24

9 The relative atomic mass of oxygen is 16 and that of hydrogen is 1.

This means that … (i) … of oxygen has the same mass as … (ii) … of hydrogen.

Which words correctly complete the gaps?

	gap (i)	gap (ii)
A	an atom	thirty-two molecules
B	an atom	eight molecules
C	a molecule	sixteen atoms
D	a molecule	eight atoms

0620_s/03/qp1

Question 25

9 The table shows the numbers of atoms present in the formula of some compounds.

Which row is **not** correct?

	numbers of atoms	formula
A	1 × calcium, 1 × carbon, 3 × oxygen	$CaCO_3$
B	1 × carbon, 5 × hydrogen, 1 × oxygen	C_2H_5OH
C	1 × hydrogen, 1 × oxygen, 1 × sodium	NaOH
D	2 × hydrogen, 4 × oxygen, 1 × sulfur	H_2SO_4

0620_w/14/qp13

Question 26

9 How many atoms of hydrogen are there in a molecule of ethanol, C_2H_5OH?

A 1 **B** 2 **C** 5 **D** 6

0620_w/14/qp11

Question 27

10 Iron forms an oxide with the formula Fe_2O_3.

What is the relative formula mass of this compound?

A 76 **B** 100 **C** 136 **D** 160

0620_w/14/qp11

Question 28

9 The formulae of compounds W, X and Y are shown.

W $CuSO_4.5H_2O$

X $MgSO_4.7H_2O$

Y $Cu(NO_3)_2.6H_2O$

Which statement is correct?

A W contains twice as many hydrogen atoms as oxygen atoms.

B X contains the most oxygen atoms.

C Y contains the most hydrogen atoms.

D Y contains the same number of hydrogen and oxygen atoms.

0620_w/13/qp11

Question 29

10 Which relative molecular mass, M_r, is **not** correct for the molecule given?

	molecule	M_r
A	ammonia, NH_3	17
B	carbon dioxide, CO_2	44
C	methane, CH_4	16
D	oxygen, O_2	16

0620_w/13/qp11

Question 30

8 A compound has the formula CH_3CO_2H.

How should the relative molecular mass, M_r, of this compound be calculated?

A 12 + 1 + 16

B 3(12 + 1) + 2(12 + 16) + 1

C (4 × 12) + (2 × 1) + 16

D (2 × 12) + (4 × 1) + (2 × 16)

0620_w/12/qp11

Question 31

8 The relative formula mass, M_r, of copper(II) sulfate, $CuSO_4$, is 160.

Which mass of sulfur is present in 160 g of copper(II) sulfate?

A 16 g **B** 32 g **C** 64 g **D** 128 g

0620_w/11/qp11

Question 32

10 The chemical compositions of two substances, W and X, are given.

W $Na(AlSi_3)O_8$

X $Ca(Al_2Si_2)O_8$

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

0620_w/10/qp11

Question 33

10 For each atom of carbon present in a molecule, there is an equal number of atoms of oxygen but twice as many atoms of hydrogen.

What is the formula of the molecule?

A $C_2H_2O_2$ **B** $C_2H_2O_4$ **C** $C_2H_4O_2$ **D** C_2H_6O

0620_w/09/qp11

Question 34

11 Water is formed when 48 g of oxygen combine with 6 g of hydrogen.

What mass of oxygen combines with 2 g of hydrogen?

A 12 g **B** 16 g **C** 96 g **D** 144 g

0620_w/09/qp11

Question 35

10 Lead(II) nitrate can be decomposed as shown.

$$xPb(NO_3)_2 \rightarrow yPbO + zNO_2 + O_2$$

Which numbers x, y and z balance the equation?

	x	y	z
A	2	2	2
B	2	2	4
C	2	4	4
D	4	4	2

0620_w/08/qp1

IGCSE 0620 – Theory Questions

Question 1

(c) An analysis of the compound, $Pb(C_2H_5)_n$, showed that 0.026 moles of Pb was combined with 0.104 moles of C_2H_5 groups.
What is the value of n? Show how you arrived at your answer.

.....

..... [2]

0620/w11/qp32

Question 2

(c) Insoluble salts are made by precipitation. An equation for the preparation of barium sulfate is given below.

$$BaCl_2(aq) + MgSO_4(aq) \rightarrow BaSO_4(s) + MgCl_2(aq)$$

This reaction can be used to find x in the formula for hydrated magnesium sulfate $MgSO_4.xH_2O$.

A known mass of hydrated magnesium sulfate, $MgSO_4.xH_2O$, was dissolved in water. Excess aqueous barium chloride was added. The precipitate of barium sulfate was filtered, washed and dried. Finally it was weighed.

Mass of hydrated magnesium sulfate = 1.476 g

Mass of barium sulfate formed = 1.398 g

The mass of one mole of $BaSO_4$ = 233 g

The number of moles of $BaSO_4$ formed = ... [1]

The number of moles of $MgSO_4.xH_2O$ = ... [1]

The mass of one mole of $MgSO_4.xH_2O$ = ... g [1]

The mass of one mole of $MgSO_4$ = 120 g

The mass of xH_2O in one mole of $MgSO_4.xH_2O$ = ... [1]

x = ... [1]

0620/w11/qp32

Question 3

(c) There are three possible equations for the thermal decomposition of sodium hydrogencarbonate.

$2NaHCO_3(s) \rightarrow Na_2O(s) + 2CO_2(g) + H_2O(g)$ **equation 1**

$NaHCO_3(s) \rightarrow NaOH(s) + CO_2(g)$ **equation 2**

$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(g)$ **equation 3**

The following experiment was carried out to determine which one of the above is the correct equation.

A known mass of sodium hydrogencarbonate was heated for ten minutes. It was then allowed to cool and weighed.

Results
Mass of sodium hydrogencarbonate = 3.36 g
Mass of the residue = 2.12 g

Calculation
M_r for $NaHCO_3$ = 84 g; M_r for Na_2O = 62 g; M_r for NaOH = 40 g
M_r for Na_2CO_3 = 106 g

(i) Number of moles of $NaHCO_3$ used = ... [1]

(ii) If residue is Na_2O, number of moles of Na_2O = ...

If residue is NaOH, number of moles of NaOH = ...

If residue is Na_2CO_3, number of moles of Na_2CO_3 = ... [2]

(iii) Use the number of moles calculated in **(i)** and **(ii)** to decide which one of the three equations is correct. Explain your choice.

.....

.....

..... [2]

0620/w11/qp31

Question 4

(b) 6.0 g of cobalt(II) carbonate was 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 = ...

Number of moles of $CoCl_2$ formed = ...

Number of moles of $CoCl_2.6H_2O$ formed = ...

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

Maximum yield of $CoCl_2.6H_2O$ = ... g [4]

To show that cobalt(II) carbonate is in excess

Number of moles of HCl used = ... (use value from above)

Mass of one mole of $CoCO_3$ = 119 g

Number of moles of $CoCO_3$ in 6.0 g of cobalt(II) carbonate = ... [1]

Explain why cobalt(II) carbonate is in excess .....

..... [1]

0620/w10/qp31

Question 5

(d) 20.0 cm^3 of sulfuric acid, concentration 0.30 mol/dm^3, was added to 40 cm^3 of sodium hydroxide, concentration 0.20 mol/dm^3.

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

(i) How many moles of H_2SO_4 were added? ..... [1]

(ii) How many moles of NaOH were used? ..... [1]

(iii) Which reagent is in excess? Give a reason for your choice.

reagent in excess ..... [1]

reason .....

..... [1]

(iv) Is the pH of the final mixture less than 7, equal to 7 or more than 7?

..... [1]

0620/w10/qp32

Question 6

(b) (i) In an experiment, a 60 cm^3 sample of biogas required 80 cm^3 of oxygen for the complete combustion of the methane in the sample.
Calculate the percentage of methane in the sample of biogas. Assume that biogas contains only methane and carbon dioxide.

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

.....

.....

..... [2]

(ii) Carbon dioxide is acidic and methane is neutral.
Suggest another way of measuring the volume of methane in the sample.

.....

..... [2]

0620/w10/qp32

Question 7

(b) Maleic acid is an unsaturated acid. 5.8 g of this acid contained 2.4 g of carbon, 0.2 g of hydrogen and 3.2 g of oxygen.

(i) How do you know that the acid contained only carbon, hydrogen and oxygen?

.....

..... [1]

(ii) Calculate the empirical formula of maleic acid.

Number of moles of carbon atoms = ...

Number of moles of hydrogen atoms = ...

Number of moles of oxygen atoms = ...

The empirical formula is ..... [3]

(iii) The mass of one mole of maleic acid is 116 g. What is its molecular formula?

..... [2]

(iv) Maleic acid is dibasic. One mole of acid produces two moles of H^+. Deduce its structural formula.

[2]

0620/w10/qp33

Question 8

(c) 9.12 g of anhydrous iron(II) sulfate was heated. Calculate the mass of iron(III) oxide formed and the volume of sulfur trioxide, at r.t.p., formed.

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

mass of one mole of $FeSO_4$ = 152 g

number of moles of $FeSO_4$ used = ...

number of moles of Fe_2O_3 formed = ...

mass of one mole of Fe_2O_3 = ... g

mass of iron(III) oxide formed = ... g

number of moles of SO_3 formed = ...

volume of sulfur trioxide formed = ... dm^3

[6]

0620/w09/qp31

Question 9

7 The alkanes are generally unreactive. Their reactions include combustion, substitution and cracking.

(a) The complete combustion of an alkane gives carbon dioxide and water.

(i) 10 cm^3 of butane is mixed with 100 cm^3 of oxygen, which is an excess. The mixture is ignited. What is the volume of unreacted oxygen left and what is the volume of carbon dioxide formed?

$$C_4H_{10}(g) + 6\tfrac{1}{2}O_2(g) \longrightarrow 4CO_2(g) + 5H_2O(l)$$

Volume of oxygen left = ... cm^3

Volume of carbon dioxide formed = ... cm^3 [2]

0620/w08/qp3

Question 10

(b) Benzene contains 92.3% of carbon and its relative molecular mass is 78.

(i) What is the percentage of hydrogen in benzene?

..... [1]

(ii) Calculate the ratio of moles of C atoms: moles of H atoms in benzene.

.....

..... [2]

(iii) Calculate its empirical formula and **then** its molecular formula.

The empirical formula of benzene is .....

The molecular formula of benzene is ..... [2]

0620/w08/qp3

Question 11

(c) **(i)** Calculate the mass of one mole of $Fe_2O_3.2H_2O$.

..... [1]

(ii) Use your answer to **(i)** to calculate the percentage of iron in rust.

.....

..... [2]

0620/w08/qp3

Question 12

(ii) One piece of marble, 0.3 g, was added to 5 cm^3 of hydrochloric acid, concentration 1.00 mol / dm^3. Which reagent is in excess? Give a reason for your choice.

mass of one mole of $CaCO_3$ = 100 g

number of moles of $CaCO_3$ = ...

number of moles of HCl = ...

reagent in excess is .....

reason ..... [4]

(iii) Use your answer to **(ii)** to calculate the maximum volume of carbon dioxide produced measured at r.t.p.

..... [1]

0620/w07/qp3

Question 13

6 An ore of copper is the mineral, chalcopyrite. This is a mixed sulphide of iron and copper.

(a) Analysis of a sample of this ore shows that 13.80 g of the ore contained 4.80 g of copper, 4.20 g of iron and the rest sulphur.
Complete the table and calculate the empirical formula of chalcopyrite.

	copper	iron	sulphur
composition by mass / g	4.80	4.20	
number of moles of atoms			
simplest mole ratio of atoms			

[3]

The empirical formula is

..... [1]

0620/w06/qp3

Question 14

3 Calcium carbonate is an important raw material.

(a) Name a rock which is made up of calcium carbonate.

..... [1]

(b) When calcium carbonate is heated strongly, it decomposes.

$$CaCO_3 \rightarrow CaO + CO_2$$

(i) Calculate the relative formula mass of:

$CaCO_3$ .....

CaO ..... [2]

(ii) 7.00 kg of calcium oxide was formed. What mass of calcium carbonate was heated?

.....

..... [2]

0620/w06/qp3

Question 15

6 (a) The following method is used to make crystals of hydrated nickel sulphate.

An excess of nickel carbonate, 12.0 g, was added to 40 cm^3 of sulphuric acid, 2.0 mol/dm^3. The unreacted nickel carbonate was filtered off and the filtrate evaporated to obtain the crystals.

$$NiCO_3 + H_2SO_4 \longrightarrow NiSO_4 + CO_2 + H_2O$$
$$NiSO_4 + 7H_2O \longrightarrow NiSO_4.7H_2O$$

Mass of one mole of $NiSO_4.7H_2O$ = 281 g
Mass of one mole of $NiCO_3$ = 119 g

(i) Calculate the mass of unreacted nickel carbonate.

Number of moles of H_2SO_4 in 40 cm^3 of 2.0 mol/dm^3 acid = 0.08

Number of moles of $NiCO_3$ reacted = ...

Mass of nickel carbonate reacted = ... g

Mass of unreacted nickel carbonate = ... g [3]

(ii) The experiment produced 10.4 g of hydrated nickel sulphate. Calculate the percentage yield.

The maximum number of moles of $NiSO_4.7H_2O$ that could be formed =

.....

The maximum mass of $NiSO_4.7H_2O$ that could be formed = ... g

The percentage yield = ... % [3]

0620/w05/qp3

Question 16

(c) Iron(III) sulphate decomposes when heated. Calculate the mass of iron(III) oxide formed and the volume of sulphur trioxide produced when 10.0 g of iron(III) sulphate was heated.
Mass of one mole of $Fe_2(SO_4)_3$ is 400 g.

$$Fe_2(SO_4)_3\,(s) \longrightarrow Fe_2O_3\,(s) + 3SO_3\,(g)$$

Number of moles of $Fe_2(SO_4)_3$ = ……

Number of moles of Fe_2O_3 formed = ……

Mass of iron(III) oxide formed = …… g

Number of moles of SO_3 produced = ……

Volume of sulphur trioxide at r.t.p. = …… dm^3 [5]

0620/w04/qp3

Question 17

(d) Sulphur dioxide reacts with chlorine in an addition reaction to form sulphuryl chloride.

$$SO_2 + Cl_2 \longrightarrow SO_2Cl_2$$

8.0 g of sulphur dioxide was mixed with 14.2 g of chlorine. The mass of one mole of SO_2Cl_2 is 135 g.

Calculate the mass of sulphuryl chloride formed by this mixture.

Calculate the number of moles of SO_2 in the mixture = ……

Calculate the number of moles of Cl_2 in the mixture = ……

Which reagent was not in excess? ……

How many moles of SO_2Cl_2 were formed = ……

Calculate the mass of sulphuryl chloride formed = …… g [5]

0620/w03/qp3

Question 18

(f) Sodium reacts with sulphur to form sodium sulphide.

$$2Na + S \rightarrow Na_2S$$

An 11.5 g sample of sodium is reacted with 10 g of sulphur. All of the sodium reacted but there was an excess of sulphur.
Calculate the mass of sulphur left unreacted.

(i) Number of moles of sodium atoms reacted = ...
[2 moles of Na react with 1 mole of S]

(ii) Number of moles of sulphur atoms that reacted = ...

(iii) Mass of sulphur reacted = ...g

(iv) Mass of sulphur left unreacted = ...g [4]

0620/w02/qp3

Question 19

(c) The results of an investigation into the action of heat on copper(II) sulphate-5-water, a blue crystalline solid, are given below.

The formula is $CuSO_4.5H_2O$ and the mass of one mole is 250 g

A 5.0 g sample of the blue crystals is heated to form 3.2 g of a white powder. With further heating this decomposes into a black powder and sulphur trioxide.

(i) Name the white powder.

.....[1]

(ii) What is observed when water is added to the white powder?

.....[1]

(iii) Name the black powder.

.....[1]

(iv) Calculate the mass of the black powder. Show your working.

.....

.....

.....[3]

0620/w02/qp3

Question 20

(e) The titanium ore contains 36.8% iron, 31.6% titanium and the remainder is oxygen.

(i) Determine the percentage of oxygen in this titanium compound.

percentage of oxygen = ... % [1]

(ii) Calculate the number of moles of atoms for each element.
The number of moles of Fe is shown as an example.
number of moles of Fe = 36.8 / 56 = 0.66

number of moles of Ti = ...

number of moles of O = ... [1]

(iii) What is the simplest ratio for the moles of atoms?

Fe	:	Ti	:	O
.....		.....		.....

[1]

(iv) What is the formula of this titanium compound?

..... [1]

0620/s10/qp31

Question 21

(ii) 20 cm^3 of a gaseous hydrocarbon was mixed with an excess of oxygen, 200 cm^3. The mixture was ignited. After cooling, 40 cm^3 of oxygen and 100 cm^3 of carbon dioxide remained. Deduce the formula of the hydrocarbon and the equation for its combustion. All volumes were measured at r.t.p..

.....

.....

.....

.....

..... [3]

0620/s14/qp33

Question 22

(b) Using 25.0 cm^3 of aqueous lithium hydroxide, concentration 2.48 mol/dm^3, 2.20 g of hydrated lithium sulfate was obtained.
Calculate the percentage yield, giving your answer to **one** decimal place.

$$2LiOH + H_2SO_4 \rightarrow Li_2SO_4 + 2H_2O$$

$$Li_2SO_4 + H_2O \rightarrow Li_2SO_4.H_2O$$

Number of moles of LiOH used = ...

Number of moles of $Li_2SO_4.H_2O$ which could be formed = ...

Mass of one mole of $Li_2SO_4.H_2O$ = 128 g

Maximum yield of $Li_2SO_4.H_2O$ = ... g

Percentage yield = ...% [4]

(c) An experiment was carried out to show that the formula of the hydrated salt is $Li_2SO_4.H_2O$. A sample of the hydrated salt was weighed and its mass recorded. It was then heated and the anhydrous salt was weighed. This procedure was repeated until two consecutive masses were the same. This procedure is called 'heating to constant mass'.

(i) What is the reason for heating to constant mass?

..... [1]

(ii) The mass of the hydrated salt is m_1 and the mass of the anhydrous salt is m_2. Explain how you could show that the hydrated salt has **one** mole of water of crystallisation per mole of the anhydrous salt.

.....

.....

..... [3]

0620/s14/qp32

Question 23

(d) In the first experiment, the maximum volume of oxygen produced was 96 cm^3 measured at r.t.p. Calculate the concentration of the aqueous hydrogen peroxide in mol/dm^3.

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

number of moles of O_2 formed = ... [1]

number of moles of H_2O_2 in 40 cm^3 of solution = ... [1]

concentration of the aqueous hydrogen peroxide in mol/dm^3 = ...

..... [1]

0620/s14/qp31

Question 24

8 **(a)** Define the following

(i) the mole

.....

..... [1]

(ii) the Avogadro constant

.....

..... [1]

(b) Which **two** of the following contain the same number of molecules?
Show how you arrived at your answer.

2.0 g of methane, CH_4
8.0 g of oxygen, O_2
2.0 g of ozone, O_3
8.0 g of sulfur dioxide, SO_2

.....

.....

..... [2]

(c) 4.8 g of calcium is added to 3.6 g of water. The following reaction occurs.

$$Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$$

(i) the number of moles of Ca = ...

the number of moles of H_2O = ... [1]

(ii) Which reagent is in excess? Explain your choice.

.....

..... [2]

(iii) Calculate the mass of the reagent named in **(ii)** which remained at the end of the experiment.

.....

..... [1]

[Total: 8]

0620/s13/qp33

Question 25

(d) 20 cm^3 of a hydrocarbon was burnt in 175 cm^3 of oxygen. After cooling, the volume of the remaining gases was 125 cm^3. The addition of aqueous sodium hydroxide removed carbon dioxide leaving 25 cm^3 of unreacted oxygen.

(i) volume of oxygen used = ... cm^3 [1]

(ii) volume of carbon dioxide formed = ... cm^3 [1]

(iii) Deduce the formula of the hydrocarbon and the balanced equation for the reaction.

.....

.....

.....

..... [2]

0620/s13/qp33

Question 26

(b) The concentration of the hydrochloric acid was 2.20 mol / dm^3. The volume of acid needed to neutralise the 25.0 cm^3 of lithium hydroxide was 20.0 cm^3. Calculate the concentration of the aqueous lithium hydroxide.

$$LiOH + HCl \rightarrow LiCl + H_2O$$

.....

.....

..... [2]

(c) Lithium chloride forms three hydrates. They are $LiCl.H_2O$, $LiCl.2H_2O$ and $LiCl.3H_2O$. Which **one** of these three hydrates contains 45.9 % of water?
Show how you arrived at your answer.

.....

.....

..... [3]

0620/s13/qp31

Question 27

(e) 0.01 moles of an alkene needed 2.4 g of oxygen for complete combustion. 2.2 g of carbon dioxide were formed. Determine the following mole ratio.

moles of alkene : moles of O_2 : moles of CO_2

From this ratio determine the formula of the alkene.

..... [3]

Write an equation for the complete combustion of this alkene.

..... [1]

[Total: 13]

0620/s12/qp32

Question 28

(b) A sample of rust had the following composition:

51.85 g of iron 22.22 g of oxygen 16.67 g of water.

Calculate the following and then write the formula for this sample of rust.

number of moles of iron atoms, Fe = ... [1]

number of moles of oxygen atoms, O = ... [1]

number of moles of water molecules, H_2O = ... [1]

simplest mole ratio Fe : O : H_2O is ..... : ..... : .....

formula for this sample of rust is ..... [1]

0620/s12/qp31

Question 29

8 Hydrocarbons are compounds which contain only carbon and hydrogen.

(a) 20 cm^3 of a gaseous hydrocarbon was burned in 120 cm^3 of oxygen, which is in excess. After cooling, the volume of the gases remaining was 90 cm^3. Aqueous sodium hydroxide was added to remove carbon dioxide, 30 cm^3 of oxygen remained. All volumes were measured at r.t.p..

(i) Explain why it is essential to use excess oxygen.

.....

..... [2]

(ii) Carbon dioxide is slightly soluble in water. Why does it dissolve readily in the alkali, sodium hydroxide?

..... [1]

(iii) Complete the following.

volume of gaseous hydrocarbon = ...cm^3

volume of oxygen used = ...cm^3

volume of carbon dioxide formed = ...cm^3 [2]

(iv) Use the above volume ratio to find the mole ratio in the equation below and hence find the formula of the hydrocarbon.

.....$C_xH_y(g)$ + ...$O_2(g)$ → .....$CO_2(g)$ + ...$H_2O(l)$

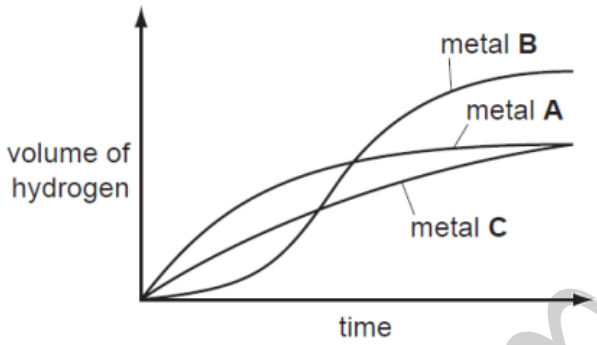
hydrocarbon formula = ... [2]

0620/s11/qp32

Question 30

7 Excess hydrochloric acid was added to powdered zinc. The hydrogen evolved was collected and its volume measured every 20 seconds.

The experiments were repeated at the same temperature using the same number of moles of powdered magnesium and aluminium.



(a) Identify metals **A**, **B** and **C** by choosing from zinc, magnesium and aluminium. Give a reason for each choice.

metal **A** .....

.....

metal **B** .....

.....

metal **C** .....

..... [5]

(b) Using 'moles', explain why two of the metals form the same volume of hydrogen but the third metal forms a larger volume.

.....

.....

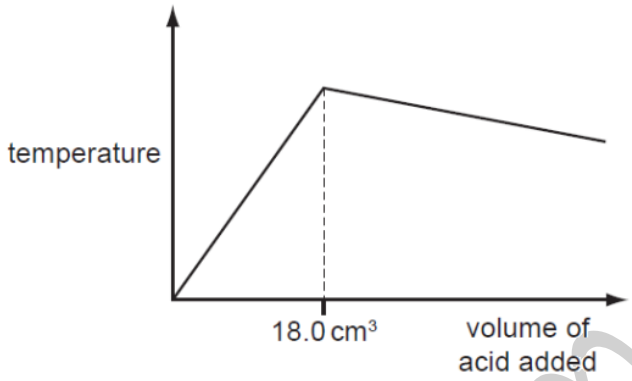
..... [3]

[Total: 8]

0620/s11/qp31

Question 31

(d) 20.0 cm^3 of aqueous sodium hydroxide, 2.00 mol / dm^3, was placed in a beaker. The temperature of the alkali was measured and 1.0 cm^3 portions of hydriodic acid were added. After each addition, the temperature of the mixture was measured. Typical results are shown on the graph.



$$NaOH(aq) + HI(aq) \rightarrow NaI(aq) + H_2O(l)$$

(i) Explain why the temperature increases rapidly at first then stops increasing.

.....

..... [2]

(ii) Suggest why the temperature drops after the addition of 18.0 cm^3 of acid.

..... [1]

(iii) In another experiment, it was shown that 15.0 cm^3 of the acid neutralised 20.0 cm^3 of aqueous sodium hydroxide, 1.00 mol / dm^3. Calculate the concentration of the acid.

.....

..... [2]

0620/s11/qp31

Question 32

(c) A 5.00 g sample of impure lead(II) nitrate was heated. The volume of oxygen formed was 0.16 dm^3 measured at r.t.p. The impurities did not decompose.
Calculate the percentage of lead(II) nitrate in the sample.

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

Number of moles of O_2 formed = ...

Number of moles of $Pb(NO_3)_2$ in the sample = ...

Mass of one mole of $Pb(NO_3)_2$ = 331 g

Mass of lead(II) nitrate in the sample = ... g

Percentage of lead(II) nitrate in sample = ... [4]

0620/s10/qp32

Question 33

9 Quantities of chemicals, expressed in moles, can be used to find the formula of a compound, to establish an equation and to determine reacting masses.

(a) A compound contains 72% magnesium and 28% nitrogen. What is its empirical formula?

.....

.....

.....

..... [2]

(b) A compound contains only aluminium and carbon. 0.03 moles of this compound reacted with excess water to form 0.12 moles of $Al(OH)_3$ and 0.09 moles of CH_4.

Write a balanced equation for this reaction.

.....

.....

.....

..... [2]

(c) 0.07 moles of silicon reacts with 25 g of bromine.

$$Si + 2Br_2 \longrightarrow SiBr_4$$

(i) Which one is the limiting reagent? Explain your choice.

.....

.....

.....

.....

..... [3]

(ii) How many moles of $SiBr_4$ are formed?

..... [1]

[Total: 8]

0620/s09/qp31

Question 34

(b) Using 25.0 cm^3 of aqueous sodium hydroxide, 2.24 mol / dm^3, 3.86 g of crystals were obtained. Calculate the percentage yield.

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

$$Na_2SO_4 + 10H_2O \longrightarrow Na_2SO_4.10H_2O$$

Number of moles of NaOH used = ...

Maximum number of moles of $Na_2SO_4.10H_2O$ that could be formed = ...

Mass of one mole of $Na_2SO_4.10H_2O$ = 322 g

Maximum yield of sodium sulphate-10-water = ... g

Percentage yield = ... % [4]

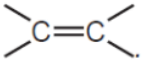
0620/s08/qp31

Question 35

(d) A better way of measuring the degree of unsaturation is to find the iodine number of the unsaturated compound. This is the mass of iodine that reacts with all the double bonds in 100 g of the fat.

Use the following information to calculate the number of double bonds in one molecule of the fat.

Mass of one mole of the fat is 884 g.

One mole of I_2 reacts with one mole 

The iodine number of the fat is 86.2 g.

Complete the following calculation.

100 g of fat reacts with 86.2 g of iodine.

884 g of fat reacts with ..... g of iodine.

One mole of fat reacts with ..... moles of iodine molecules.

Number of double bonds in one molecule of fat is ..... [3]

[Total: 14]

0620/s07/qp3

Question 36

(d) Propene reacts with hydrogen iodide to form 2-iodopropane.

$CH_3–CH=CH_2 + HI \longrightarrow CH_3–CHI–CH_3$

1.4 g of propene produced 4.0 g of 2-iodopropane.

Calculate the percentage yield.

moles of $CH_3–CH=CH_2$ reacted = ...

maximum moles of $CH_3–CHI–CH_3$ that could be formed = ...

mass of one mole of $CH_3–CHI–CH_3$ = 170 g

maximum mass of 2-iodopropane that could be formed = ...

percentage yield ..... % [4]

0620/s06/qp3

Question 37

(d) Gypsum is hydrated calcium sulphate, $CaSO_4.xH_2O$. It contains 20.9% water by mass. Calculate x.

M_r: $CaSO_4$, 136; H_2O, 18.

79.1 g of $CaSO_4$ = ... moles

20.9 g of H_2O = ... moles

x = ... [3]

0620/s05/qp3

Question 38

(c) 0.015 moles of iodine react with 0.045 moles of chlorine to form 0.030 moles of a single product. Complete the equation.

I_2 + ... Cl_2 → ..... [2]

0620/s05/qp3

Question 39

7 Chemists use the concept of the mole to calculate the amounts of chemicals involved in a reaction.

(a) Define *mole*.

.....

[1]

(b) 3.0 g of magnesium was added to 12.0 g of ethanoic acid.

$Mg + 2CH_3COOH \rightarrow (CH_3COO)_2Mg + H_2$

The mass of one mole of Mg is 24 g.

The mass of one mole of CH_3COOH is 60 g.

(i) Which one, magnesium or ethanoic acid, is in excess? You must show your reasoning.

.....

.....

.....

[3]

(ii) How many moles of hydrogen were formed?

.....

[1]

(iii) Calculate the volume of hydrogen formed, measured at r.t.p.

.....

[2]

(c) In an experiment, 25.0 cm^3 of aqueous sodium hydroxide, 0.4 mol / dm^3, was neutralised by 20.0 cm^3 of aqueous oxalic acid, $H_2C_2O_4$.

$$2NaOH + H_2C_2O_4 \rightarrow Na_2C_2O_4 + 2H_2O$$

Calculate the concentration of the oxalic acid in mol / dm^3.

(i) Calculate the number of moles of NaOH in 25.0 cm^3 of 0.4 mol / dm^3 solution.

.....

[1]

(ii) Use your answer to **(i)** and the mole ratio in the equation to find out the number of moles of $H_2C_2O_4$ in 20 cm^3 of solution.

.....

[1]

(iii) Calculate the concentration, mol / dm^3, of the aqueous oxalic acid.

.....

[2]

0620/s04/qp3

Question 40

(c) Each tablet contains the same number of moles of $CaCO_3$ and $MgCO_3$. One tablet reacted with excess hydrochloric acid to produce 0.24 dm^3 of carbon dioxide at r.t.p.

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + CO_2 + H_2O$$
$$MgCO_3 + 2HCl \rightarrow MgCl_2 + CO_2 + H_2O$$

(i) Calculate how many moles of $CaCO_3$ there are in one tablet.

number of moles CO_2 = ...

number of moles of $CaCO_3$ and $MgCO_3$ = ...

number of moles of $CaCO_3$ = ...

[3]

(ii) Calculate the volume of hydrochloric acid, 1.0 mol / dm^3, needed to react with one tablet.

number of moles of $CaCO_3$ and $MgCO_3$ in one tablet = ...
Use your answer to **(c)(i)**.

number of moles of HCl needed to react with one tablet = ...

volume of hydrochloric acid, 1.0 mol / dm^3, needed to react with one tablet = ...

[2]

0620/s03/qp3

Question 41

(c) 6.31 g of cobalt(II) chloride-6-water crystals were obtained. Calculate the percentage yield to 1 decimal place.

number of moles of HCl in 50 cm^3 of acid, concentration 2.2 mol / dm^3 = ...

maximum number of moles of $CoCl_2.6H_2O$ which could be formed = ...

mass of 1 mole of $CoCl_2.6H_2O$ = 238 g

maximum yield of $CoCl_2.6H_2O$ = ... g

percentage yield = ...%

[4]

0620/w14/qp33

Question 42

(b) Compound X is a hydrocarbon. It contains 85.7% of carbon. The mass of one mole of X is 84 g.

(i) What is the percentage of hydrogen in the compound ?

..... [1]

(ii) Calculate the empirical formula of X. Show your working.

empirical formula = ... [3]

(iii) What is the molecular formula of compound X?

..... [1]

0620/w14/qp33

Question 43

(iii) A mineral of the type $FeSO_4.xH_2O$ contains 37.2% of water.
Complete the calculation to determine x.

mass of one mole of H_2O = 18 g

mass of water in 100 g of $FeSO_4.xH_2O$ = 37.2 g

number of moles of H_2O in 100 g of $FeSO_4.xH_2O$ = ...

mass of $FeSO_4$ in 100 g of $FeSO_4.xH_2O$ = ... g

mass of one mole of $FeSO_4$ = 152 g

number of moles of $FeSO_4$ in 100 g of $FeSO_4.xH_2O$ = ...

x = ...

[4]

0620/w14/qp32

Question 44

(ii) 6.0 g of ethanoic acid, M_r = 60, was reacted with 5.5 g of ethanol, M_r = 46.
Determine which is the limiting reagent and the maximum yield of ethyl ethanoate, M_r = 88.

number of moles of ethanoic acid = ... [1]

number of moles of ethanol = ... [1]

the limiting reagent is ..... [1]

number of moles of ethyl ethanoate formed = ... [1]

maximum yield of ethyl ethanoate = ... [1]

0620/w14/qp31

Question 45

(ii) What mass of silver(I) nitrate is needed to prepare 100 cm^3 of silver(I) nitrate solution, concentration 0.2 mol/dm^3?
The mass of one mole of $AgNO_3$ is 170 g.

.....

..... [2]

(iii) What is the maximum mass of silver(I) chromate(VI) which could be obtained from 20 cm^3 of aqueous silver(I) nitrate, concentration 0.2 mol/dm^3?

number of moles of $AgNO_3$ used = ... [1]

number of moles of Ag_2CrO_4 formed = ... [1]

mass of one mole of Ag_2CrO_4 = 332 g

mass of Ag_2CrO_4 formed = ... g [1]

0620/w13/qp32

Question 46

(c) Basic lead(II) carbonate has a formula of the type $xPbCO_3.yPb(OH)_2$ where x and y are whole numbers.
Determine x and y from the following information.

$$PbCO_3 \rightarrow PbO + CO_2$$

$$Pb(OH)_2 \rightarrow PbO + H_2O$$

When heated, the basic lead(II) carbonate gave 2.112 g of carbon dioxide and 0.432 g of water.

Mass of one mole of CO_2 = 44 g
Mass of one mole of H_2O = 18 g

Number of moles of CO_2 formed = ... [1]

Number of moles of H_2O formed = ... [1]

x = ... and y = ...

Formula of basic lead(II) carbonate is ..... [1]

0620/w13/qp31

Question 47

(d) Calculate the maximum mass of carbon dioxide given off when 20.0 g of small lumps of calcium carbonate react with 40 cm^3 of hydrochloric acid, concentration 2.0 mol/dm^3.

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

number of moles of HCl used =

mass of carbon dioxide = ... g [4]

0620/w13/qp31

Question 48

(b) Another hydride of arsenic has the composition below.

arsenic 97.4 % hydrogen 2.6 %

(i) Calculate the empirical formula of this hydride **from the above data**.
Show your working.

.....

.....[2]

(ii) The mass of one mole of this hydride is 154 g. What is its molecular formula?

..... [1]

(iii) Deduce the structural formula of this hydride.

[1]

0620/w12/qp33

Question 49

(d) Sulfur dioxide can also be made by the reaction between a sulfite and an acid.

$$Na_2SO_3 + 2HCl \rightarrow 2NaCl + SO_2 + H_2O$$

Excess hydrochloric acid was added to 3.15 g of sodium sulfite. Calculate the maximum volume, measured at r.t.p., of sulfur dioxide which could be formed.
The mass of one mole of Na_2SO_3 is 126 g.

.....

.....

..... [3]

0620/w12/qp32

Question 50

(c) In the above experiment, 50.0 cm^3 of hydrochloric acid of concentration 2.0 mol/dm^3 was used. 6.4 g of $SrCl_2.6H_2O$ was made.
Calculate the percentage yield.

number of moles of HCl used = ...

number of moles of $SrCl_2.6H_2O$ which could be formed = ...

mass of one mole of $SrCl_2.6H_2O$ is 267 g

theoretical yield of $SrCl_2.6H_2O$ = ...g

percentage yield = ...% [4]

0620/w12/qp31

Question 51

(c) Fluorine, the most reactive halogen, forms compounds with the other halogens. It forms two compounds with bromine.
Deduce their formulae from the following information.

compound 1
The mass of one mole of this compound is 137 g.

Its formula is ..... [1]

compound 2
0.02 moles of this compound contain 0.02 moles of bromine atoms and 0.1 moles of fluorine atoms.

Its formula is ..... [1]

0620/w12/qp31

0620 MCQ Answers

1-A	**11-C**	**21-C**	**31-B**
2-D	**12-B**	**22-D**	**32-B**
3-D	**13-D**	**23-B**	**33-C**
4-B	**14-C**	**24-B**	**34-B**
5-C	**15-C**	**25-B**	**35-B**
6-B	**16-D**	**26-D**	
7-	**17-C**	**27-D**	
8-	**18-C**	**28-D**	
9-C	**19-D**	**29-D**	
10-D	**20-B**	**30-D**	

0620 Theory Answers

Question 1

(c) 0.104/0.026 [1]

n = 4

Question 2

(c) mass of hydrated magnesium sulfate = 1.476 g

mass of barium sulfate formed = 1.398 g

the mass of one mole of $BaSO_4$ = 233 g

the number of moles of $BaSO_4$ formed = 0.006 [1]

the number of moles of $MgSO_4.xH_2O$ used in experiment = 0.006 [1]

the mass of one mole of $MgSO_4.xH_2O$ = 1.476/0.006 = 246 g [1]

the mass of xH_2O in one mole of $MgSO_4.xH_2O$ = 246 – 120 = 126 g [1]

x = 126/18 = 7 [1]

if x given without method = max 1

note: apply ecf but x must be an integer and less than 10

Question 3

(c) calculation:

Mr for $NaHCO_3$ = 84 g; Mr for Na_2O = 62 g; Mr for NaOH = 40 g

Mr for Na_2CO_3 = 106 g

(i) number of moles of $NaHCO_3$ used = 3.36/84 = 0.04 [1]

(ii) if residue is Na_2O, number of moles of Na_2O = 2.12/62 =0.034 / 0.03

if residue is NaOH, number of moles of NaOH = 2.12/40 = 0.053 / 0.05

if reside is Na_2CO_3, number of moles of Na_2CO_3 = 2.12/106 =0.02 all three correct [2]

note: two correct = 1

(iii) equation 3 [1]

mole ratio 2:1 agrees with equation [1]

Question 4

(b) number of moles of HCl used = 0.04 × 2 = 0.08

number of moles $CoCl_2$ formed = 0.04

number of moles $CoCl_2.6H_2O$ formed = 0.04

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

maximum yield of $CoCl_2.6H_2O$ = 9.52g [4]

accept 9.5 g

mark ecf to moles of HCl

do not mark ecf to integers

to show that cobalt(II) carbonate is in excess

number of moles of HCl used = 0.08 must use value above ecf

mass of one mole of $CoCO_3$ = 119g

number of moles of $CoCO_3$ in 6.0g of cobalt(II) carbonate = 6.0/119 = 0.050 [1]

reason why cobalt(II) carbonate is in excess 0.05 > 0.08/2 [1]

Question 5

(d) (i) how many moles of H_2SO_4 were added = 0.02 × 0.3 = 0.006 [1]

(ii) how many moles of NaOH were used = 0.04 × 0.2 = 0.008 [1]

(iii) sulfuric acid [1]

only mark ecf if in accord with 1:2 ratio and with values from (i) and (ii).

reason 0.006 > 0.008/2 [1]

for ecf mark candidate must use 1:2 ratio in answer

(iv) less than 7 [1]

Question 6

(b) (i) 80 cm3 of oxygen therefore 40 cm3 of methane [1]

40/60 × 100 = 66.7 % [1]

accept 66 % and 67 %

no ecf

(ii) add sodium hydroxide(aq) / alkali [1]

carbon dioxide dissolves, leaving methane [1]

Question 7

(b) (i) add up to 5.8 g [1]

(ii) moles of C atoms = 2.4/12 = 0.2

moles of H atoms = 0.2/1 = 0.2

moles of O atoms = 3.2/16 = 0.2

all three correct = 2 [2]

two correct = 1

empirical formula CHO [1]

(iii) 116/29 = 4 [1]

$C_4H_4O_4$ [1]

correct formula with no working scores both marks.

(iv) $HOOCCH=CHCOOH$ / $CH_2=C(COOH)_2$ [2]

Question 8

(c) number of moles of $FeSO_4$ used = 9.12/152 = 0.06 [1]

number of moles of Fe_2O_3 formed = 0.03* [1]

mass of one mole of Fe_2O_3 = 160 g [1]

mass of iron(III) oxide formed = 0.03 × 160 = 4.8 g [1]

number of moles of SO_3 formed = 0.03 [1]

volume of sulfur trioxide formed = 0.03 × 24 = 0.72 dm3 [1]

If mass of iron(III) oxide greater than 9.12 g, then only marks 1 and 2 available

Apply ecf to number of moles of Fe_2O_3* when calculating volume of sulfur trioxide.

Do not apply ecf to integers

Question 9

7 (a) (i) 35 cm3 [1]
40 cm3 [1]

Question 10

(b) (i) 7.7% [1]
(ii) for any number: equal number ratio [2]
for example 1:1 or 6:6
(iii) empirical formula is CH [1]
molecular formula is C6H6 [1]
no e.c.f., award of marks not dependent on (ii)

Question 11

(c) (i) 196 [1]
(ii) 112/196 × 100 [1]
= 57(.1)% ACCEPT 57 to nearest whole number [1]
mark e.c.f. to (c)(i) provided percentage not greater than 100%
ONLY ACCEPT 112/answer (c)(i) × 100
otherwise [0]

Question 12

(ii) mass of one mole of CaCO3 = 100
number of moles of CaCO3 = 0.3/100 = 0.003 [1]
moles of HCl = 5/1000 x 1 = 0.005 [1]
reagent in excess is CaCO3 [1]
ecf from above
would need 0.006 moles of HCl
or hydrochloric acid only reacts with 0.0025 moles of CaCO3 [1]
NOTE this mark needs to show recognition of the 1:2 ratio
(iii) mark ecf to (ii), that is from moles of limiting reagent in (ii)
moles of CO2 = 0.005 x 0.5 x 24 = 0.06 dm3 [1]
NOT cm3 unless numerically correct. 60 cm3
Ignore other units
NOTE If both number of moles integers then no ecf for (ii) and (iii)

Question 13

(a)
copper iron sulphur
composition by
mass/g
(4.80) (4.20) 4.8 [1]
number of moles
of atoms
0.075 0.075 0.15 [1]
simplest mole ratio
of atoms
1 1 2 [1]
[3]
The empirical formula is CuFeS2 [1]

Question 14

(b) (i) 100 [1]
56 ignore units in both cases [1]
(ii) 7.00kg is 1/8 of 56 [1]
1/8 of 100kg is 12.5kg [1]
Give both marks for correct answer without explanation.
Ignore missing units
but penalise wrong units

Question 15

Question 6
(a)(i) moles of NiCO3 reacted = 0.08 [1]
mass of nickel carbonate reacted = 9.52 g [1]
mass of nickel carbonate unreacted = 2.48 g [1]
(ii) maximum number of moles of hydrated salt = 0.08 [1]
maximum mass of salt = 0.08 x 281 = 22.48 g [1]
percentage yield 10.4/22.48 x 100 = 46.3% [1]

Question 16

Mark consequentially to any error but not involving simple integers
There has to be some evidence that the candidate has attempted to work
through the calculation and not merely inserted whole numbers.
For example 2, 1, 160 or 1, 0.5, 80
number of moles of Fe2(SO4)3 = 1/40 or 0.025
number of moles of Fe2 O3 formed = 1/40 or 0.025
mass of iron(III) oxide formed = 0.025 x 160 = 4g
number of moles of SO3 produced = 3/40 or 0.075
volume of sulphur trioxide at r.t.p. = 0.075 x 25
= 1.8dm3 [5]

Question 17

(d) the number of moles of S02 in the mixture= 0.125
the number of moles of Cb in the mixture = 0. 2
cond reagent was not in excess? S02
cond moles of S02Cb formed = 0.125
cond the mass of sulphuryl chloride formed = l 6.9g
[5]

Question 18

(f) (i) 11.5/23 = 0.5 [I]
(ii) 0.25 [1]
conseq to (i)
...
(iii) 0.25 x 32 = 8 g [I]
conseq
(iv) 2.0 g [1]
only conseq to (iii) if answer to (iii) is less than 10
NB If (ii) is 0.3(125), no excess is possible, (iv) ZERO

Question 19

(c) (i) copper sulphate or anhydrous copper sulphate [I]
accept "unhydrated"
NOT formula
(ii) goes blue or becomes hot or steam [I]

(iii) copper oxide [1]
(iv) 5/250 = 0.02 moles
Mr=80
80 x 0.02 = 1.6 g
NB (iv) to be marked conseq to (iii)
Correct answer no working ONLY [1]

Question 20

(e) (i) percentage of oxygen = 31.6 % [1]
(ii) calculate the number of moles of atoms for each element
number of moles of Ti = 31.6/48 = 0.66
number of moles of O = 31.6/16 = 1.98 accept 2 [1]
both correct for one mark
(iii) the simplest whole number ratio for moles of atoms:
Fe : Ti : O
1 1 3 [1]
(iv) formula is FeTiO3 accept TiFeO3 [1]
must be whole numbers from (iii) or cancelled numbers from (iii)
mark ecf throughout

Question 21

(ii) Volume ratio
Cx
Hy(g) + O2(g) → CO2(g) + H2O(l)
20 160 100 all in cm3
1 8 5 mole ratio
C5
H12 + 8O2 → 5CO2 + 6H2O
For evidence of method (1)
for equation as above (2) [3]

Question 22

(c) (i) (to prove) all water driven off or evaporated or boiled / no water remains / to
make salt anhydrous (1)
(ii) m1– m2 = mass of water (1)
(calculate) moles of water AND moles of hydrated or anhydrous salt (1)
1:1 ratio / should be equal (1) [3]

Question 23

(d) number of moles of O2 formed = 0.096 / 24 = 0.004 (1)
number of moles of H2O2 in 40 cm3 of solution = 0.004 × 2 = 0.008 (1)
concentration of the hydrogen peroxide in mol / dm3 = 0.008 / 0.04 = 0.2 (1) [3]

Question 24

8 (a) (i) (the number of particles which is equal to the number of atoms in) 12 g of carbon 12
or
the mass in grams which contains the Avogadro's constant number of particles
or
Avogadro's constant or 6 to 6.023 × 1023 of atoms / ions / molecules / electrons /
particles
or
(the amount of substance which has a mass equal to) its relative formula mass / relative
atomic mass / relative molecular mass in grams
or
(the amount of substance which has a volume equal to) 24 dm3 of a gas at RTP
[1]
(ii) (Avogadro's constant is the) number of particles / atoms / ions / molecules in one mole of
a substance
or
the number of carbon atoms in 12 g of C(12).
or
the number of particles / molecules in 24 dm3of a gas at RTP
or
6 to 6.023 × 1023 (particles / atoms / ions / molecules / electrons) [1]
(b) CH4 and SO2 [1]
2/16 = 1/8 or 0.125 moles of CH4 AND 8/64 = 1/8 or 0.125 moles of SO2
(c) (i) 4.8/40 = 0.12 moles of Ca
3.6/18 = 0.2 moles of H2O both correct [1]
(ii) Ca is in excess (no mark) (because 0.12 moles of Ca need)
0.24 moles / 4.32 g of H2O
to react [1]
there is not enough / there are 0.2 moles / 3.6 g of H2O [1]
or
Ca is in excess (no mark) (because 0.2 moles / 3.6 g of water will react with)
0.1moles/4.0 g of Ca [1]
there is more than that / there are 0.12 moles / 4.8 g of Ca [1]
or
Ca is in excess (no mark) because the mole ratio Ca:H2O is 3:5 / mass ratio 4:3 [1]
which is bigger than the required mole ratio of 1:2 / mass ratio 10:9 [1]
or
Ca is in excess (no mark) because the mole ratio H2O:Ca is 5:3 / mass ratio 3:4 [1]
which is smaller than the required mole ratio of 2:1 / mass ratio 9:10 [1]
(iii) 0.02 × 40 = 0.8 (g) [1]

Question 25

(d) volume of oxygen used = 150 cm3
volume of carbon dioxide formed = 100 cm3 [1]
any equation of the combustion of an alkene
e.g. 2C5H10 + 15O2 ⍰ 10CO2 + 10H2O
formulae [1]
COND balancing

Question 26

(b) number of moles of HCl = 0.020 x 2.20 = 0.044 [1]
number of moles of LiOH = 0.044
concentration of LiOH = 0.044/0.025 = 1.769 (mol / dm3) [1]

accept 1.75 to 1.77 need 2 dp
correct answer scores = 2
(c) (for LiCl.2H2O)
mass of one mole = 78.5 [1]
percentage water = 36 / 78.5 x 100 [1]
45.9 so is LiCl.2H2O [1]
only award the marks if you can follow the reasoning and it gives 45.9% of water
note: if correct option given mark this and ignore the rest of the response
allow: max 2 for applying a correct method to another hydrate, [1] for the method and [1] for
the correct value, working essential

Question 27
(e) if C5H10 is given award 3 marks;;; [3]
if C10H20 is given award 2 marks;;
if 1:7.5:5 / 2:15:10 is given award 2 marks;;
in all other cases a mark can be awarded for moles of O2 (= 2.4/32 =) 0.075 AND moles
of CO2 (= 2.2/44 =) 0.05;
2C5H10 + 15O2 → 10CO2 + 10H2O [1]
accept: multiples including fractions
allow: ecf for correct equation from any incorrect alkene

Question 28
(b) moles of Fe = 51.85/56 = 0.926 (0.93); [1]
moles of O = 22.22/16 = 1.389 (1.39); [1]
moles of H2O = 16.67/18 = 0.926 (0.93); [1]
if given as 0.9 1.4 0.9
three of the above correct = [2]
two of the above correct = [1]
simplest whole number mole ratio Fe : O : H2O is 2: 3: 2 / Fe2O3.2H2O; [1]
allow: ecf for a formula based on an incorrect whole number ratio

Question 29
8 (a) (i) (to avoid) carbon monoxide formation/so complete combustion occurs/avoid incomplete
combustion So that CO2 is produced [1]
CO does not dissolve/react with alkali [1]
(ii) CO2 is acidic [1]
(iii) volume of gaseous hydrocarbon 20 cm3
volume of oxygen used = 90 cm3 [1]
volume of carbon dioxide formed = 60 cm3 [1]
no mark for 20 cm3 of hydrocarbon.
(iv) 2C3H6(g)/2CxHy(g) + 9O2(g) → 6CO2(g) + 6H2O(l) [1]
OR … C3H6(g) + 9/2O2(g) → 3CO2(g) + 3H2O(l)
C3H6 [1]
C3H6 can be given in the equation for the second mark

Question 30
7 (a) metal A is magnesium [1]
cond most reactive or fastest reaction [1]
metal B is aluminium [1]
cond faster reaction after removal of oxide layer / it would give more hydrogen / aluminium
more reactive than zinc [1]
metal C is zinc [1]
zinc least reactive [1]
NOTE MAX [5]
If you encounter different reasoning which is correct, please award the appropriate marks.
(b) for magnesium and zinc same volume of hydrogen [1]
because both have valency of 2 / 1 mole of metal gives 1 mole of hydrogen / 1 mole of metal
reacts with 2 moles of acid [1]
bigger volume for aluminium because its valency is 3 / 1 mole of metal gives 1.5 moles of
hydrogen / 1 mole of metal reacts with 3 moles of acid [1]
If you encounter different reasoning which is correct, please award the appropriate marks.
accept balanced equations
accept ionic charges as alternative to valency

Question 31
(d) (i) the reaction is exothermic / reaction produces heat/energy [1]
all the sodium hydroxide used up/neutralised / reaction has stopped [1]
(ii) adding colder acid / no more heat produced [1]
if not given in (d)(i) any comments such as “reaction has stopped” can gain mark
(iii) 1.33 / 1.3 / 1.3333 (mol/dm3) scores both marks [2]
not 1.34
for a correct method – M1 V1 / moles of NaOH = 0.02
with an incorrect answer only [1]

Question 32
(c) if the final answer is between 86–89% award all 4
if the final answer is between 66–67% award 3 marks (Mr of 32 must have been used)
for all other answers marks can be awarded using the mark scheme as below and applying
ecf if necessary
number of moles of O2 formed = 0.16/24 = 0.0067/0.00667 or 1/150
number of moles of Pb(NO3)2 in the sample = 0.0133/0.013 or 1/75
mass of one mole of Pb(NO3)2 = 331 g
mass of lead(II) nitrate in the sample = 4.4(1) g
percentage of lead(II) nitrate in sample = 88.3% (allow 88–89) [4]
mark ecf in this question but not to simple integers
if mass of lead(II) nitrate > 5.00 only marks 1 and 2 available
If divides by 32 (not 24) only last 3 marks can score consequentially

Question 33
(a) 72/24 = 3 and 28/14 = 2 [1]
Mg3N2 [1]
accept just formula for [2] even with incorrect or no working

NOT ecf
(b) $Al_4C_3 + 12H_2O = 4Al(OH)_3 + 3CH_4$ [2]
For Al_4C_3 ONLY [1]
(c) (i) silicon is limiting reagent [1]
0.07 moles of Si and 25/160 = 0.156 moles of Br_2 [1]
because 0.14 (2 × 0.07) < 0.156 [1]
If 80 used to find moles of Br_2 the mark 1 and 3 still available
arguments based on masses can be used
(ii) 0.07 [1]
NOT ecf

Question 34
(b) number of moles of NaOH used = 0.025 x 2.24 = 0.056 [1]
maximum number of moles of $Na_2SO_4.10H_2O$ that could be formed = 0.028 [1]
mass of one mole of $Na_2SO_4.10H_2O$ = 322g
maximum yield of sodium sulphate – 10 - water = 9.02g [1]
percentage yield = 42.8% [1]
mark ecf but NOT to simple integers
if ecf marking, mark to at least one place of decimals
if percentage > 100% then 3/4 maximum

Question 35
(d) 100g of fat react with 86.2g of iodine
884g of fat react with 762 g of iodine [1]
limit 762 x 2
one mole of fat reacts with 762/254 moles of iodine molecules
one mole of fat reacts with 3 moles of iodine molecules [1]
number of double bonds in one molecule of fat is 3 [1]
limit 6
consequential marking allowed provided the number of double bonds is an integer.

Question 36
(d) moles of CH_3-CH = CH_2 reacted = 1.4/42 = 0.033 [1]
conseq
maximum moles of CH_3-CH(I)-CH_3 that could be formed = 0.033 [1]
conseq
maximum mass of 2-iodopropane that could be formed = 5.61 g [1]
accept 170 x 0.033 = 5.61 and 170 x 0.033333 = 5.67
conseq unless greater than 100%
percentage yield 4.0/5.67 x 100 = 70.5% [1]
Do not mark consequently to a series of small integers. There has to be
a serious attempt to answer the question, then consequential marking is
appropriate.

Question 37
(d) mass of one mole of $CaSO_4$ = 136
moles of $CaSO_4$ in 79.1g = 0.58 accept 0.6 [1]
moles of H_2O in 20.9 g = 1.16 accept 1.2 [1]
conseq x = 2 x given as an integer [1]

Question 38
(c) $I_2 + 3Cl_2 = 2ICl_3$ [2]
For having either reactants or products correct ONLY [1]

Question 39
skip

Question 40
(c) (i) number of moles CO_2 = 0.24/24 = 0.01
conseq number of moles of $CaCO_3$ and $MgCO_3$ = 0.01
conseq number of moles of $CaCO_3$ = 0.005 [3]
(ii) Calculate the volume of hydrochloric acid, 1.0 mole/dm3, needed to react with
one tablet.
number of moles of $CaCO_3$ and $MgCO_3$ in one tablet = 0.01
Expect same as answer to (c)(i). NO marks to be awarded. Just mark
consequentially to this response
conseq number of moles of HCl needed
to react with one tablet = 0.02
conseq volume of hydrochloric acid, 1.0 mole/dm3, needed to react with one
tablet = 0.02 dm3 or 20 cm3
[1]
[1]

Question 41
(c) number of moles of HCl in 50 cm3 of acid, concentration 2.2 mol/dm3 = 0.11 [1]
maximum number of moles of $CoCl_2.6H_2O$ which could be formed = 0.055 [1]
mass of 1 mole of $CoCl_2.6H_2O$ = 238 g
maximum yield of $CoCl_2.6H_2O$ = 13.09 g [1]
percentage yield = 48.2% or ecf mass of $CoCl_2.6H_2O$ above/13.09 × 100% to 1
dp [1]

Question 42
(b) (i) 14.3 [1]
(ii) 85.7 ÷ 12 and 14.3 ÷ 1 or 7.14 and 14.3 [1]
ratio 1:2 [1]
CH_2 [1]
note: Award all 3 marks for correct answer
allow: alternative working e.g.
85.7 × 84 ÷ 100 and 14.3 × 84 ÷ 100 or 71.988/72 and 12/12.012 [1]
6:12 or ratio 1:2 [1]
CH_2 [1]
(iii) C_6H_{12} [1]

Question 43
(iii) M1 = 2.07 Allow 2.1 or 2.0666…7
M2 = 62.8.g
M3 =(M2/152 =) 0.41(3)
M4 (=M1/M3) rounded to the nearest whole number × = 5 [4]

Question 44

(ii) number of moles of ethanoic acid = 0.1 [1]
number of moles of ethanol = 0.12(0) [1]
the limiting reagent is ethanoic acid [1]
number of moles of ethyl ethanoate formed = 0.1 [1]
maximum yield of ethyl ethanoate is 8.8 g [1]

Question 45

(ii) mass of $AgNO_3$ needed is $170 \times 0.2 \times 0.1 = 3.4$g [2]
NOTE: if answer given is 34 they have omitted 0.1
ALLOW: (1) ecf
(iii) number of moles of $AgNO_3$ used = $0.02 \times 0.2 = 0.004$ [1]
number of moles of Ag_2CrO_4 formed = 0.002 [1]
mass of one mole of Ag_2CrO_4 = 332g
mass of Ag_2CrO_4 formed = 0.664g [1]
NOTE: use ecf when appropriate

Question 46

(c) number of moles of CO_2 formed = 2.112 / 44 = 0.048 [1]
number of moles of H_2O formed = 0.432 / 18 = 0.024 [1]
x = 2 and y = 1 NOT: ecf from this line
formula is $2PbCO_3.Pb(OH)_2$ / $Pb(OH)_2.2PbCO_3$ [1]

Question 47

(d) number of moles of HCl in 40 cm3 of hydrochloric acid, concentration 2.0 mol / dm3 = $0.04 \times 2.0 = 0.08$ [1]
maximum number of moles of CO_2 formed = 0.04 [1]
mass of one mole of CO_2 = 44 g [1]
maximum mass of CO_2 lost = $0.04 \times 44 = 1.76$ g [1]

Question 48

(b) (i) (97.4 / 75 =) 1.3 and (2.6 / 1 =) 2.6; [1]
empirical formula AsH_2; [1]
note: correct formula with no working = [1]
(ii) As_2H_4; [1]
(iii) $H_2As–AsH_2$ / $AsH_2–AsH_2$; [1]

Question 49

(d) number of moles of Na_2SO_3 = 3.15/126 = 0.025 [1]
number of moles of SO_2 formed = 0.025 [1]
volume of SO_2 = 0.025 x 24 = 0.6 dm3/litres or 600 cm3 [1]
allow: ecf
for 1.6 g of SO_2 [1] only
If used 22.4 max [2]
note: need correct units for last mark

Question 50

(c) number of moles of HCl used = $0.05 \times 2 = 0.1$ [1]
number of moles of $SrCl_2.6H_2O$ which could be formed. = 0.05 [1]
mass of one mole of $SrCl_2.6H_2O$ is 267 g
theoretical yield of $SrCl_2.6H_2O$ = $0.05 \times 267 = 13.35$ g [1]
percentage yield = $6.4 / 13.35 \times 100 = 47.9\%$ [1]
accept: 48%
allow: ecf

Question 51

(c) BrF_3 / F_3Br; [1]
BrF_5 / F_5Br; [1]