Quantitative Chemistry 3

Name: _____

Class: _____

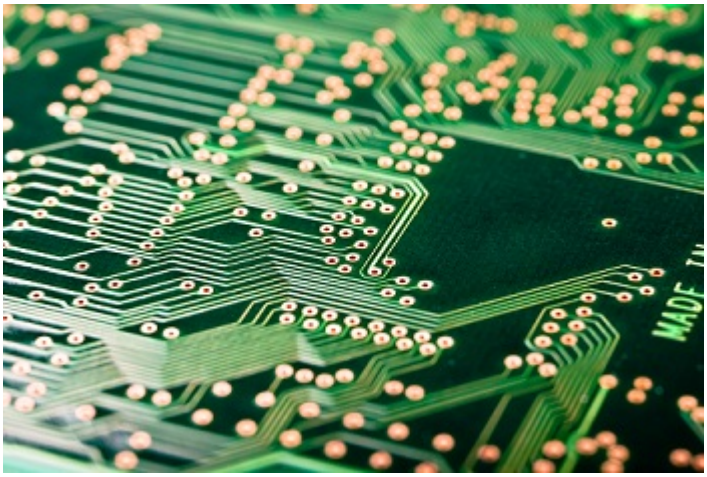
Date: _____

Time: **57 minutes**

Marks: **57 marks**

Comments:

1. Etching is a way of making printed circuit boards for computers.



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Printed circuit boards are made when copper sheets are etched using iron(III) chloride solution. Where the copper has been etched, only plastic remains.

(a) Copper is a good conductor of electricity.

Explain why.

_____

_____

_____

_____

(2)

(b) Iron(III) chloride can be produced by the reaction shown in the equation:

$$2\ Fe + 3\ Cl_2 \rightarrow 2\ FeCl_3$$

(i) Calculate the maximum mass of iron(III) chloride ($FeCl_3$) that can be produced from 11.20 g of iron.

Relative atomic masses (A_r): Cl = 35.5; Fe = 56.

_____

_____

_____

_____

_____

Maximum mass of iron(III) chloride = _____ g

(3)

(ii) The actual mass of iron(III) chloride ($FeCl_3$) produced was 24.3 g.

Calculate the percentage yield.

(If you did not answer part (b)(i) assume that the maximum theoretical mass of iron(III) chloride ($FeCl_3$) is 28.0 g. This is **not** the correct answer to part (b)(i).)

_____

_____

Percentage yield = _____%

(1)

(Total 6 marks)

2. Iron is an essential part of the human diet. Iron(II) sulfate is sometimes added to white bread flour to provide some of the iron in a person's diet.

(a) The formula of iron(II) sulfate is $FeSO_4$

Calculate the relative formula mass (M_r) of $FeSO_4$

Relative atomic masses: O = 16; S = 32; Fe = 56.

_____

_____

The relative formula mass (M_r) = _____

(2)

(b) What is the mass of one mole of iron(II) sulfate? Remember to give the unit.

_____

(1)

(c) What mass of iron(II) sulfate would be needed to provide 28 grams of iron?

Remember to give the unit.

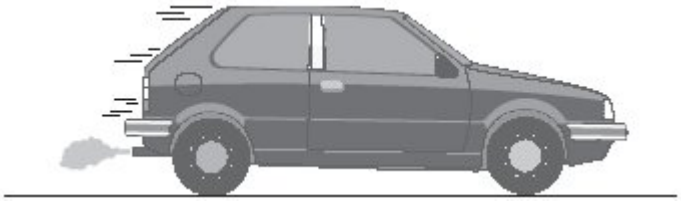
_____

(1)

(Total 4 marks)

3. Petrol is a mixture of hydrocarbons such as octane, C_8H_{18}

When petrol is burned in a car engine, a large amount of carbon dioxide is produced.



This car uses 114 g of petrol to travel one mile.

Calculate the mass of carbon dioxide produced when this car travels one mile.

Assume that petrol is octane and that combustion is complete.

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

The combustion of octane can be represented by this equation.

$$C_8H_{18} + 12\tfrac{1}{2}\ O^2 \rightarrow 8CO_2 + 9H_2O$$

_____

_____

_____

_____

_____

_____

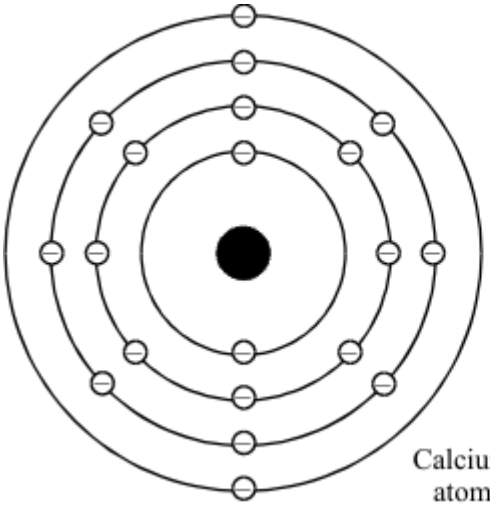
Mass of carbon dioxide = _____ g

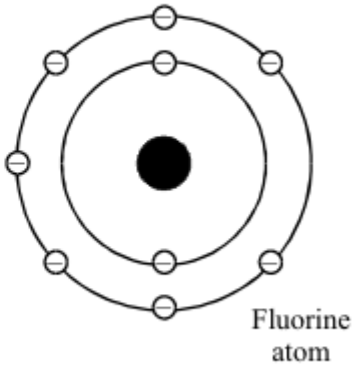
(Total 3 marks)

4. Uranium metal can be produced by reacting uranium hexafluoride with calcium.

$UF_6 + 3Ca \rightarrow 3CaF_2 + U$

(a) Describe how calcium and fluorine bond together to form calcium fluoride. The electron arrangement of each atom is shown.





(5)

(b) Uranium has two main isotopes, $^{235}_{92}U$ and $^{238}_{92}U$. Use these as examples to explain what is meant by the word isotope.

(4)

(c) At the start of a reaction there was 174.5 g of uranium hexafluoride, UF_6.

Relative atomic masses: F 19; U 235

(i) Calculate the relative formula mass of uranium hexafluoride, UF_6.

_____

_____

_____

Relative formula mass UF_6 = _____ g

(1)

(ii) Calculate the mass of uranium that would be produced from 134.5 g of uranium hexafluoride.

_____

_____

_____

_____

_____

Mass of uranium = _____ g

(2)

(Total 12 marks)

5. Follow the steps to find the percentage of iron in iron oxide.

Relative atomic masses: O 16; Fe 56.

(i) Step 1

Calculate the relative formula mass of iron oxide, Fe_2O_3.

_____

_____

(1)

(ii) Step 2

Calculate the total relative mass of just the iron atoms in the formula, Fe_2O_3.

_____

(1)

(iii) Step 3

Calculate the percentage (%) of iron in the iron oxide, Fe_2O_3.

_____

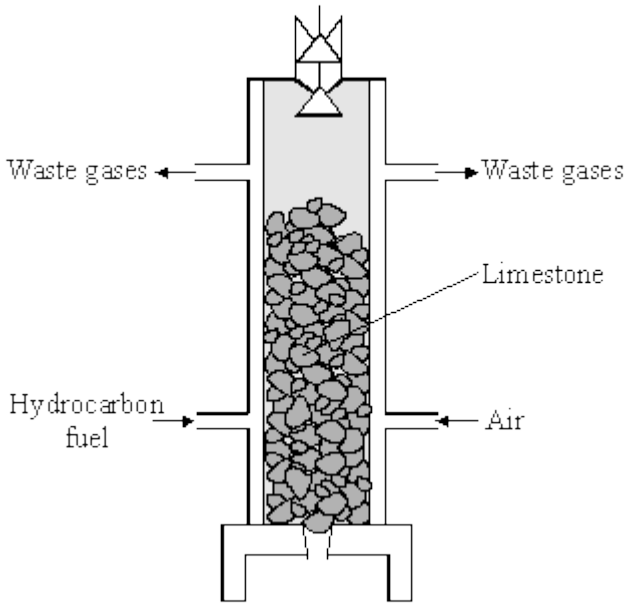
_____

Percentage of iron _____ %

(1)

(Total 3 marks)

6. Limestone is a useful mineral. Every day, large amounts of limestone are heated in limekilns to produce lime. Lime is used in the manufacture of iron, cement and glass and for neutralising acidic soils.



$$CaCO_3 \rightleftharpoons CaO + CO_2$$

(i) The decomposition of limestone is a *reversible* reaction. Explain what this means.

_____

_____

_____

_____

(2)

(ii) Calculate the mass of lime, CaO, that would be produced from 250 tonnes of limestone, $CaCO_3$.

Relative atomic masses: C 12; O 16; Ca 40.

Mass of lime = _____ tonnes

(3)

(Total 5 marks)

7. Ammonium nitrate is an important fertiliser. It is made by reacting nitric acid with the alkali ammonia.

(i) State the type of reaction taking place.

(1)

(ii) The equation for this reaction is:

$NH_3 + HNO_3 \rightarrow NH_4NO_3$

Calculate the number of tonnes of ammonium nitrate that can be made from 68 tonnes of ammonia.

(Relative atomic masses: H = 1, N = 14, O = 16)

(3)

(Total 4 marks)

8. Iron is the most commonly used metal. Iron is extracted in a blast furnace from iron oxide using carbon monoxide.

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

(a) A sample of the ore haematite contains 70% iron oxide.

Calculate the amount of iron oxide in 2000 tonnes of haematite.

_____

_____

Amount of iron oxide = _____ tonnes

(1)

(b) Calculate the amount of iron that can be extracted from 2000 tonnes of haematite.
(Relative atomic masses: O = 16; Fe = 56)

_____

_____

_____

_____

_____

_____

Amount of iron = _____ tonnes

(4)

(Total 5 marks)

9. Calculate the percentage of iron in iron sulphate ($FeSO_4$).

(Relative atomic masses: Fe = 56, O = 16, S = 32)

_____

_____

_____

_____

Percentage of iron in iron sulphate = _____%

(Total 3 marks)

10. The balanced symbol equation for the reaction is

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

Starting with 2 g of hydrogen, what mass of hydrogen chloride would be produced?
(Relative atomic masses: H = 1; Cl = 35.5)

Mass of hydrogen chloride = _____ g

(Total 3 marks)

11. Ammonium chloride, NH_4Cl, is made up of nitrogen, hydrogen and chlorine atoms.

(i) Complete the table to show the number of atoms of each element present in NH_4Cl.

Element	**Number of atoms in NH_4Cl**
nitrogen	1
hydrogen	
chlorine	

(1)

(ii) Calculate the relative formula mass of ammonium chloride, NH_4Cl.

(Relative atomic masses: H = 1, N = 14, Cl = 35.5)

Relative formula mass = _____

(2)

(Total 3 marks)

12. The information on the Data Sheet will be helpful in answering this question.

(a) Calculate the formula mass (M_r) of the compound iron (III) oxide, Fe_2O_3.

(Show your working.)

_____

_____

_____

_____

_____

(3)

(b) Calculate the mass of iron produced when 32g of iron (III) oxide is completely reduced by aluminium.

The reaction is shown in the symbol equation:

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

(Show your working.)

_____

_____

_____

_____

Answer = _____ grams

(3)

(Total 6 marks)

1.

(a) copper has delocalised electrons

accept copper has free electrons
*ignore sea of electrons **or** mobile electrons*

1

(electrons) which can move <u>through the metal / structure</u>

allow (electrons) which can carry a charge <u>through the metal / structure</u>

1

(b) (i) (M_r $FeCl_3$ =) 162.5

*correct answer with or without working gains **3** marks*
*can be credited from correct substitution in step **2***

1

or

2 (moles of) $FeCl_3$ = 325

or

112 → 325

$$\frac{11.20}{56} \times 162.5$$

allow ecf from step 1
accept $\frac{325}{112} \times 11.2$

1

= 32.5

accept 32.48

1

(ii) 74.8

accept 74.77 – 75
accept ecf from (b)(i)
if there is no answer to part(i)
or
if candidate chooses not to use their answer then accept 86.79 – 87

1

[6]

2.

(a) 152 correct answer with **or** without working = **2 marks**
56 + 32 + (4 ×16) gains **1** mark

ignore any units

2

(b) 152g(rams)

ecf from the answer to (a) and g

must have unit g / gram / gramme / grams etc

accept g / mol ***or*** *g per mole* ***or*** *g mole^{-1}* ***or*** *g/mol* ***or*** *g per mol* ***or*** *g mol^{-1}*

do ***not*** *accept g m*

do ***not*** *accept G*

1

(c) 76(g)

ecf from their answer to (a) or (b) divided by 2

ignore units

1

[4]

3. 352 g gains **3** marks

(moles C_8H_{18} = 114 / 114 = 1 mole)
moles CO_2 = 8 (1)
mass CO_2 = 8 × 44 (1) = 352 g (1)

1 *mark for each point*
(ecf allowed between parts)

or

114 → 8 (1) × 44

(1)

114 → 352 g

(1)

ecf allowed between parts

[3]

4. (a) calcium atom loses two electrons

accept diagrams with correct labelling

1

(each) fluorine atom gains one electron

accept two electrons transfer from a calcium atom to the two fluorine atoms for these first ***two*** *marks*

1

forming full (outer) shells of electrons

*accept forming full (outer) energy levels **or** noble gas electronic structures*

*do **not** accept stable unless qualified*

1

giving the ions Ca^{2+} and F^-

1

attraction between ions of opposite charges

accept electrostatic attraction between ions

*if candidate mentions sharing **or** pairing of electrons then no credit*

*if explanation is entirely correct but they state this is called covalent bonding, the maximum mark is **four***

1

(b) atoms of the same element

1

atomic number is same

accept each contains 92 or same number of protons

1

mass numbers differ **or** each has a different number of neutrons

1

one has 146 neutrons the other has 143 neutrons

*accept one has three more **or** less neutrons than the other*

1

(c) (i) 349

1

(ii) 349g UF_2 produces 235g U [1]

first mark can be awarded if answer is incorrect

answer = 117.5

1

[12]

5. (i) 160

ignore units

1

(ii) 112

ignore units

1

(iii) 70

*do **not** carry forward errors*

1

[3]

6. (i) a reaction in which the products can be changed back to reactants

*accept a reaction that can go forwards **or** backwards*

1

under certain conditions

1

(ii) M_r $CaCO_3$ = 100

1

M_r CaO = 56

1

mass of CaO = 140 (tonnes)

1

mark consequentially

[5]

7. (i) neutralisation/acid base reaction

for 1 mark

1

(ii) 17 (tonnes)
give 80 (tonnes) (even if only in working)

for 1 mark each

320 (tonnes) or alternative method)

3 marks for correct answer

(if 17 and 80 not given allow 1 mark for correct answer using their figures)

3

[4]

8. (a) 1400

1

(b) 980

correct answer gains full credit

160 tonnes Fe_2O_3 produces 112 tonnes Fe

if incorrect allow one mark for relative formula mass iron oxide = 160
allow e.c.f.

1400 tonnes Fe_2O_3 will produce 1400 / 160 × 112 tonnes Fe

use of 2000 tonnes Fe_2O_3 – deduct one mark only if working out is correct

4

[5]

9. 36.8 / 37

correct answer, no workings = 3 if incorrect, allow 1 mark for rfm $FeSO_4$ = 152
***or** if incorrect rfm, allow 1 mark for 56/Y × 100 where Y is incorrect formula mass*

allow 2 marks for $\frac{56}{152} \times 100$

[3]

10. 73 (seventy three)

if answer is incorrect allow 1 mark for the correct proportion that H_2:HCl is 1:2
and 1 mark for 36.5

[3]

11. (i) 4 **and** 1

both answers must be correct

1

(ii) 53.5

if incorrect relative formula mass
allow 1 mark for correct working
accept e.c.f. from c(i) for 2 marks

2

[3]

12. (a) Fe_2 [56 × 2] **or** 112
O_3 [16 × 3] **or** 48

each gain 1 mark

but M_r = 160

gains 3 marks

3

(b) [$Fe_2O_3 + 2A1 \rightarrow 2Fe + A1_2O_3$]

160 → 112 (NB Credit if unworked
(or value from (a)) (or value but should be totalled) from (a))

gains 1 mark

but
32 g. of Fe_2O_3 → 32/160 × 112

gains 2 marks

but = 22.4

gains 3 marks

3

[6]