Chemistry paper two

Stretch and challenge booklet

Exam command words

Command words are the words and phrases used in exams that tell students how they should answer a question.

The following command words are taken from Ofqual's official list of command words and their meanings that are relevant to this subject.

Calculate	Use numbers in the question to work these out.	**Draw**	Produce, or add a diagram.
Choose	Select from a range of alternatives.	**Estimate**	Give an approximate value.
Compare	Describe similarities/differences.	**Use**	The answer must include the information in the question.
Define	Specify the meaning of something.	**Work out**	Students should use numbers in the question.
Describe	Recall facts, events or process in an accurate way.	**Write**	Short answer, no explanation or description.
Design	Set out how something will be done.	**Evaluate**	Students should use the information provided as well as their own knowledge and consider evidence for or against.
Determine	Use the data provided to work out your answer.	**Explain**	Students should make something clear, or state reasons for something happening.
Give	Short answer only.	**Identify**	Name or characterise.
Label	Add words to complete a diagram, picture or graph	**Justify**	Use evidence from the information supplied to support your answer.
Measure	Find an item of data for a given quantity.	**Name**	Single word or phrase.
Plot	Mark on a graph.	**Plan**	Write a method.
Predict	Give a plausible outcome.	**Show**	Provide structured evidence to reach a conclusion.
Suggest	Apply your own knowledge.	**Sketch**	Draw approximately.

Scientific key words

These are keywords often used in questions. You need to be able to recognise and use them in your answers.

Hypothesis	A scientific statement that explains certain facts or observations	**Anomaly**	A result that does not fit the pattern
Prediction	This describes what you think will happen in an experiment	**Accuracy**	How close the reading is to the true value
Independent variable	This is the variable that is changed during an investigation. There should only be one of these.	**True value**	This is the real value of a measurement in an experiment
Dependent variable	This is the variable that changes as a result of a change in the independent variable	**Precision**	This is determined by the scale on the measuring apparatus e.g. a ruler marked mm is more precise than one in cm
Control variable	Variables that remain constant, to make sure that an investigation is valid	**Resolution**	The smallest change that can be read from a measuring device for example a ruler measured in mm or cm
Fair test	This is where only the independent variable is changed and the others controlled	**Calibration**	When we make sure that the measuring apparatus is making correct readings e.g. the temperature of melting ice is 0 degrees Celsius
Valid	The results and conclusions will be this if the variables are correctly controlled	**Measurement error**	The difference between the real value and the measured value
Categoric variable	A variable that can be described by a label or category such as colour or surface	**Random error**	This error causes measurements to be spread around the true value – can be reduced by taking repeats and calculating a mean
Continuous variable	A variable which can have any numerical value	**Zero error**	When a piece of measuring equipment should be reading zero but it doesn't
Interval	This is the difference between the values of your independent variable	**Systematic error**	This is an error that is always the same for each repeat – usually because of an error in the equipment used
Range	The maximum and minimum values of the independent or dependent variables e.g. 'from 10cm to 50cm'	**Uncertainty**	When the results obtained are not as accurate as they could be due to the procedure carried out
Data	Information or measurements that you collect	**Repeatable**	If the same person can get the same reading using the same equipment and method
Datum	One piece of information	**Reproducible**	If another person can get the same result (trend/specific results) using the same method and equipment or with different method or equipment.

Trilogy Chemistry paper 2 Revision checklist

Rates and extent of chemical reactions		
Describe ways of measuring rates of reaction – e.g mass/volume of product in a specific amount of time		
Use collision theory to explain why rates of reaction slow down as they progress		
Describe and explain patterns in graphs showing rates of reaction		
Calculate rates of reaction given data or graphs, using change/time, **including drawing tangents to a curve**		
Describe and explain how reactions are affected by temperature, concentration, surface area, pressure (gaseous reactions) & catalysts		
Explain what is meant by a reversible reaction and know how to represent them in equations		
Define the terms ‘closed system’, ‘yield’ and ‘dynamic equilibrium’		
Predict the energy change in a reversible reaction given information about one of the reactions		
Describe factors that can affect the position of equilibrium		
HT Apply Chatelier’s principle to any given reaction to predict the effects on yield of changing temperature, pressure or concentration of reactants		
Predict optimum yield conditions given some information about a reversible reaction		
Explain why the conditions chosen industrially are often ‘compromise’ conditions		
Organic chemistry		
Define a hydrocarbon		
Describe the structure of crude oil		
Describe uses of crude oil – fuels, feedstock for petrochemicals etc		
Name and draw the first five alkanes		
Describe how the properties of alkanes change with increasing chain length		
Describe how the different chain lengths are separated using fractional distillation		
Describe complete and incomplete combustion of alkanes and represent and recognise equations showing this		
Explain why cracking is necessary		
Describe different methods for cracking		
State the products of cracking		
Represent cracking using equations		
Describe the test for alkenes and its positive result		
Chemical Analysis		
Define a pure substance and a formulation		

Describe how purity can be checked using melting and boiling points		
Give some examples of formulations		
Describe how soluble substances can be separated using paper chromatography		
Interpret chromatograms		
Calculate Rf values for given chromatograms		
Describe the test and positive results for chlorine gas, hydrogen, oxygen and carbon dioxide		
The evolution of the atmosphere		
Give the approximate composition of Earth's atmosphere today		
Describe the likely composition of Earth's early atmosphere		
Describe and explain how Earth's atmosphere has changed – condensation, sedimentation, photosynthesis etc		
Name the two greenhouse gases and explain why their concentration in the atmosphere is increasing		
Explain the 'greenhouse effect' and how this is linked to climate change		
Describe some of the consequences of climate change		
Define 'carbon footprint' and give ways of reducing it		
Describe how carbon monoxide, soot, sulphur dioxide and nitrogen oxides are made		
Explain the environmental problems linked to soot, sulphur dioxide, nitrogen oxides and carbon monoxide		
Using resources		
Explain the difference between finite and renewable resources		
Evaluate the extraction of finite resources – jobs, economy, energy use, pollutants such as CO_2		
Define the term 'sustainable development'		
Define the term 'low grade ore'		
Explain how phytomining and bioleaching can be used to extract metals such as copper from low grade ore sites		
Explain the benefits of recycling or reusing metals, glass and plastics		
Explain what a 'life cycle assessment' is and why they may be biased		
Explain what 'potable' water is		
Describe how water can be made potable using distillation, filtration and sterilisation and desalination		
Evaluate the production of potable water using distillation and desalination		
Label the equipment used to distil water and explain the processes involved		
Explain the stages in sewage water treatment		

Also, from paper 1: Atomic structure & periodic table, bonding and properties of different substances, quantitative chemistry,

Required practical activities

Method writing frame:

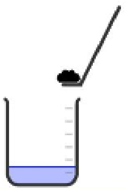
Do what? To what? How?

See example for making salts.

Making soluble salts (C5)

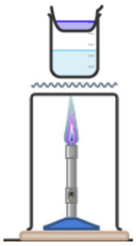
Label the diagram:

1)



2)

3)



Method:

1) Measure 50 cm^3 of dilute sulfuric acid using a measuring cylinder.
2) Gently warm the acid using a Bunsen burner. Turn off the heat before it boils.
3) Add copper oxide a spatula at time.
4) Stir the mixture using a stirring rod.
5) Continue adding copper oxide until no more will dissolve.
6) Remove the excess copper oxide by filtration.
7) Pour the filtrate into an evaporating basin.
8) Heat the evaporating basin over boiling water until crystallization starts to occur.
9) Remove the evaporating basin from the heat and leave to crystallise.

Risk assessment:

Results:

1) Write the word equation for the reaction between copper oxide and sulfuric acid.

   ____________ + ___________ → ___________ + _________

   ____________ ___________ ___________

2) Write the balanced symbol equation for this reaction.

   ____________ + ___________ → ___________ + _________

3) The reaction of copper carbonate with sulfuric acid will produce the same salt as the reaction above. Write the word equation for this reaction.

   ____________ + ___________ → _________ + _________ + _____

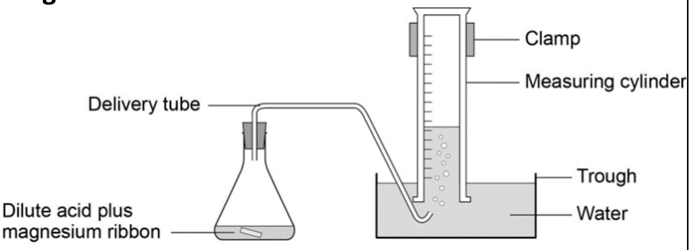
   ____________ ___________ _________ _________

4) For the reaction in Q3, how could you tell when the reaction has stopped?

   ____

Rates of reaction 1 – collecting gas (C8)

Diagram:



Independent variable:
Dependent variable:
Control variable(s):

Method:

Method (cont):

Results:

Time (s)	Volume of gas produced for 1.0 M HCl (cm^3)	Volume of gas produced for 2.0 M HCl (cm^3)
10	1	2
20	3	5
30	6	9
40	10	13
50	13	17
60	16	20
70	18	23
80	18	26
90	18	29
100	18	32

Results:

1) Plot a graph of the results. You will need two lines of best fit.

2) Describe and explain, using collision theory, the trend in the results.

Describe (say what you see):

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Explain (say **why** something happened):

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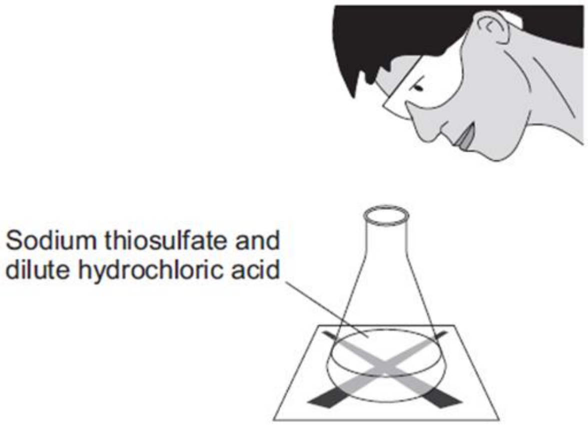
Rates of reaction 2 – measuring turbidity (C8)

Diagram:



Independent variable:

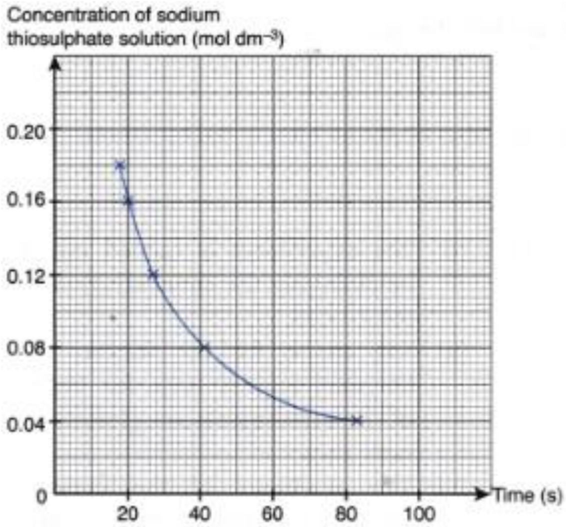
Dependent variable:

Control variable(s):

Method:

Risk assessment:

Results:



1) Describe the trend in the results.

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2) Explain the trend in the results using collision theory.

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3) At which point is the rate of reaction at its highest? How can you tell?

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4) **Higher tier:** Calculate the rate of reaction at 40 second. Give the unit.

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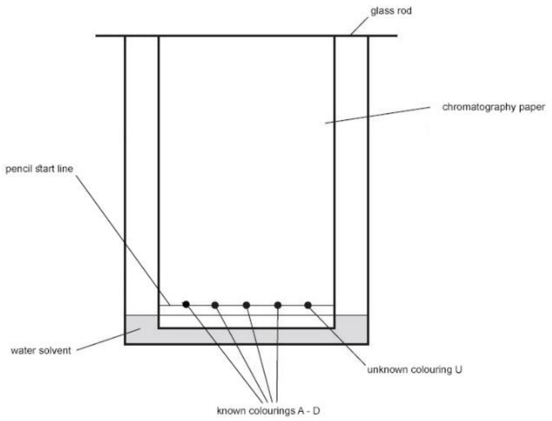
Chromatography (C12)

Diagram:



Independent variable:

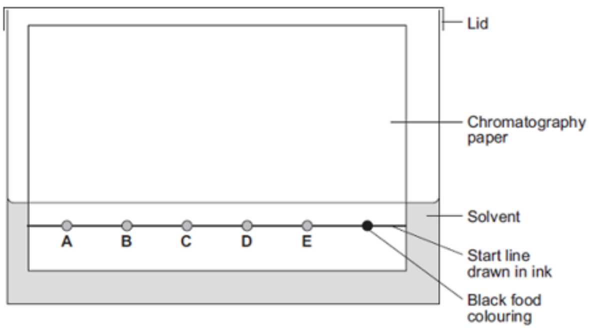
Dependent variable:

Control variable(s):

Method:

Method check:

1) Identify the **two** errors in the students' set up below and describe the problem each error would cause.



Error 1: ____________________________________
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Error 2: ____________________________________
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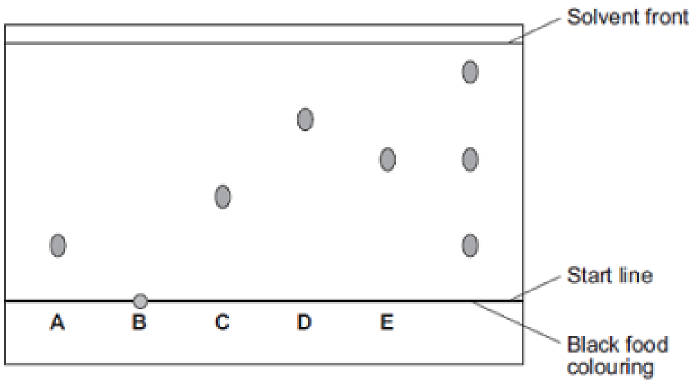
Results:

2) The student set up the experiment again and collected these results.



a) Give three conclusions that can be made about black food colouring (A – E are known food colourings).

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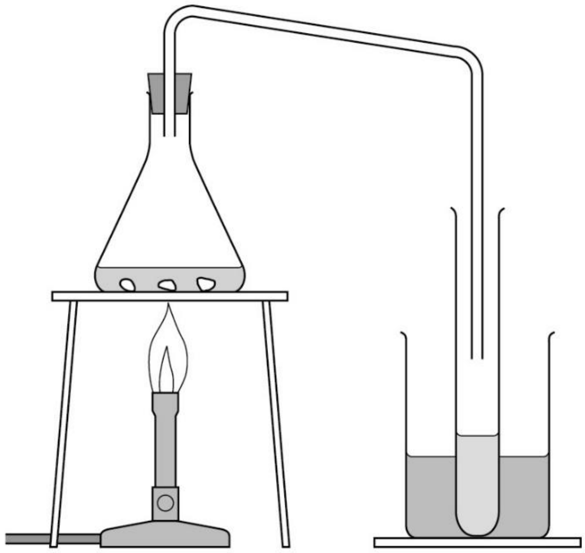
b) Calculate the Rf values of all three pigments found in black food colouring. Give your answes to 1dp.

Potable water (C14)

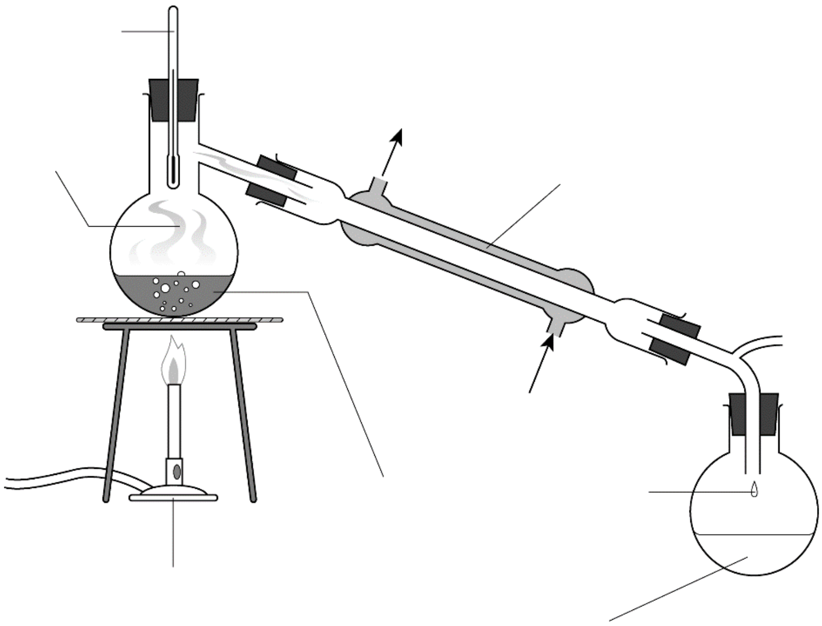
Label the diagram:



Method:

Risk assessment:

Alternative set-up. Label the diagram:



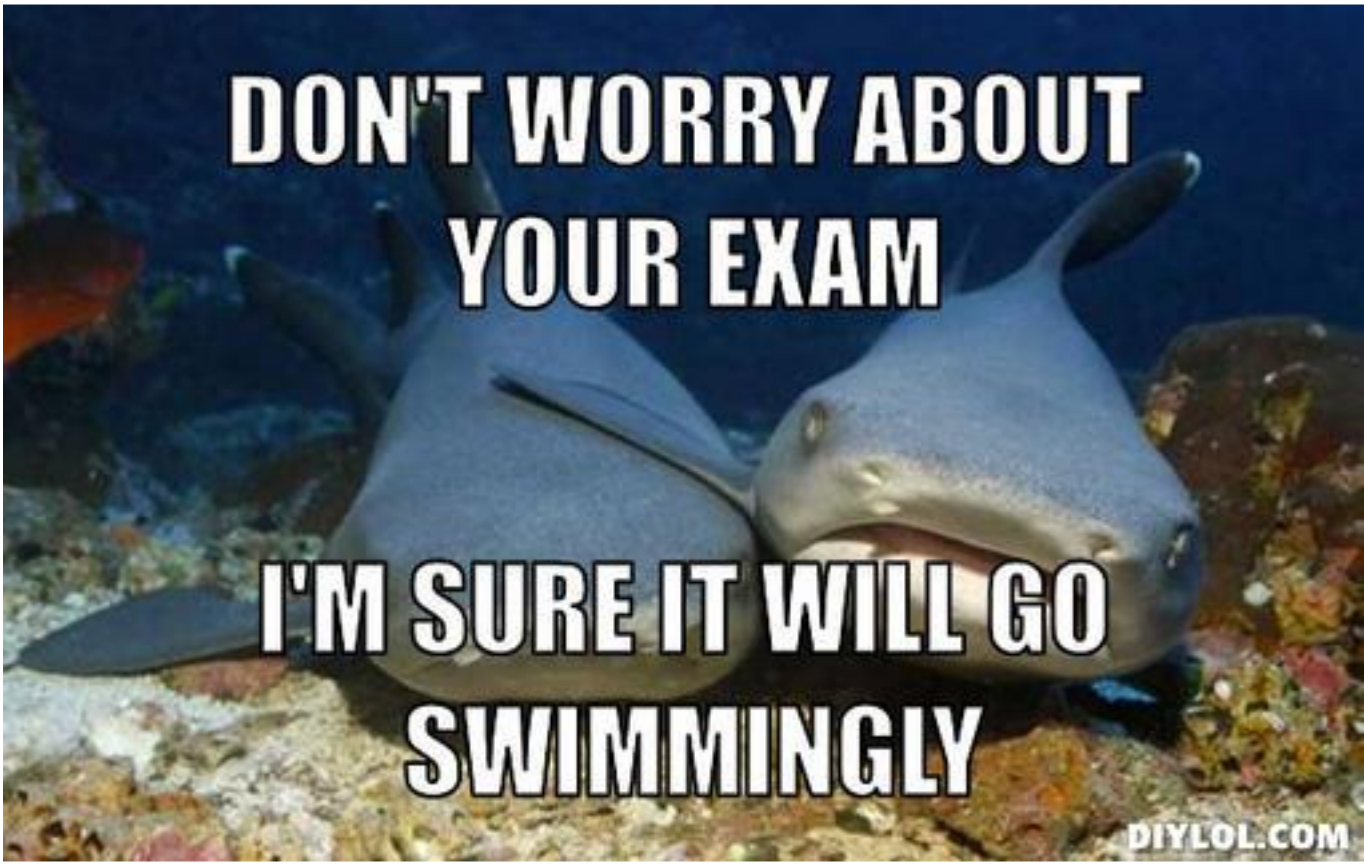
Results:

1) Describe the difference between freshwater and seawater.

2) Describe how distillation can produce potable water from seawater.

3) Explain why distillation is not used to make potable water on a large scale.

Exam questions



1. This question is about equilibrium.

(a) Describe how a reaction reaches equilibrium.

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(2)

Nitrogen dioxide gas reacts to form dinitrogen tetraoxide gas.

The reaction is reversible.

The equation for the reaction is:

$$2\ NO_2(g) \rightleftharpoons N_2O_4(g)$$

(b) Explain the effect on the equilibrium position of increasing the pressure.

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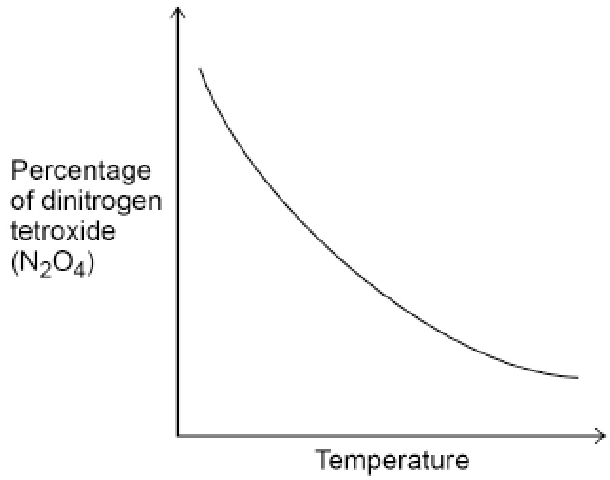
(2)

(c) The graph below shows the change in the percentage of dinitrogen tetroxide (N_2O_4) in the equilibrium mixture as the temperature of the equilibrium mixture is changed.



Explain the effect on the equilibrium position of increasing the temperature.

Use the graph above.

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(3)

(Total 7 marks)

2. Sulfur dioxide (SO_2) is used to manufacture sulfuric acid.

(a) Explain why sulfur dioxide has a low boiling point.

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(3)

(b) The equation shows one stage in the manufacture of sulfuric acid from sulfur dioxide.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The reaction is exothermic in the forward direction.

Use Le Chatelier's Principle to predict the effect of increasing the temperature on the amount of sulfur trioxide (SO_3) produced at equilibrium.

Give a reason for your answer.

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(2)

(c) Use Le Chatelier's Principle to predict the effect of increasing the pressure on the amount of sulfur trioxide (SO_3) produced at equilibrium.

Give a reason for your answer.

(2)

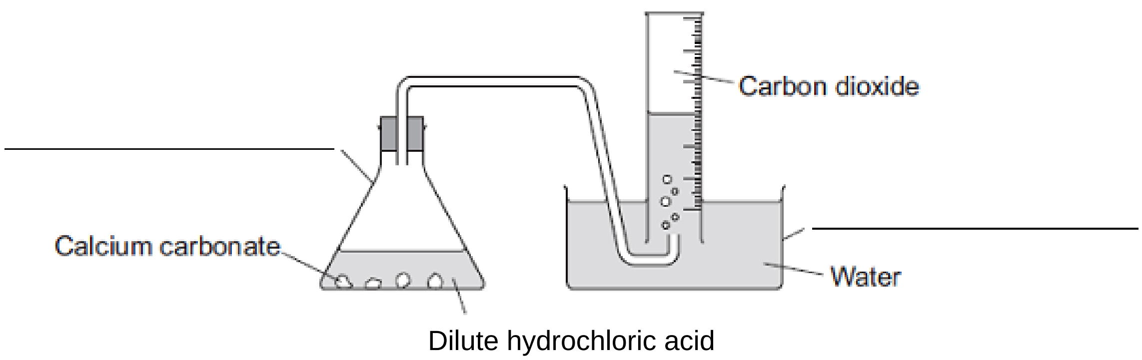
(Total 7 marks)

3. Some students were investigating the rate at which carbon dioxide gas is produced when metal carbonates react with an acid.

One student reacted 1.00 g of calcium carbonate with 50 cm^3, an excess, of dilute hydrochloric acid.

The apparatus used is shown in **Diagram 1**.

Diagram 1



(a) Complete the **two** labels for the apparatus on the diagram.

(2)

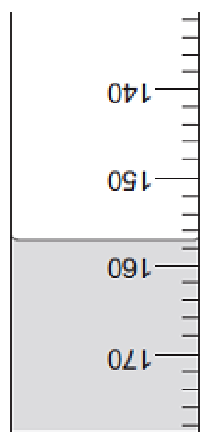
(b) The student measured the volume of gas collected every 30 seconds.

The table shows the student’s results.

Time in seconds	**Volume of carbon dioxide collected in cm^3**
30	104
60	
90	198
120	221
150	232
180	238
210	240
240	240

(i) **Diagram 2** shows what the student saw at 60 seconds.

Diagram 2



What is the volume of gas collected?

Volume of gas = ___________ cm^3

(1)

(ii) Why did the volume of gas stop changing after 210 seconds?

____

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(1)

(c) Another student placed a conical flask containing 1.00 g of a Group 1 carbonate (M_2CO_3) on a balance.

He then added 50 cm^3, an excess, of dilute hydrochloric acid to the flask and measured the mass of carbon dioxide given off.

The equation for the reaction is:

$$M_2CO_3 + 2HCl \longrightarrow 2MCl + H_2O + CO_2$$

The final mass of carbon dioxide given off was 0.32 g.

(i) Calculate the amount, in moles, of carbon dioxide in 0.32 g carbon dioxide.

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

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Moles of carbon dioxide = ___________ moles

(2)

(ii) How many moles of the metal carbonate are needed to make this number of moles of carbon dioxide?

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Moles of metal carbonate = ___________ moles

(1)

(iii) The mass of metal carbonate used was 1.00 g.

Use this information, and your answer to part **(c) (ii)**, to calculate the relative formula mass (M_r) of the metal carbonate.

If you could not answer part **(c) (ii)**, use 0.00943 as the number of moles of metal carbonate. This is **not** the answer to part **(c) (ii)**.

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Relative formula mass (M_r) of metal carbonate = ___________

(1)

(iv) Use your answer to part **(c) (iii)** to calculate the relative atomic mass (A_r) of the metal in the metal carbonate (M_2CO_3) and so identify the Group 1 metal in the metal carbonate.

If you could not answer part **(c) (iii)**, use 230 as the relative formula mass of the metal carbonate. This is **not** the answer to part **(c) (iii)**.

To gain full marks, you must show your working.

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Relative atomic mass of metal is ___________________________________

Identity of metal ____

(3)

(d) Two other students repeated the experiment in part **(c)**.

(i) When the first student did the experiment some acid sprayed out of the flask as the metal carbonate reacted.

Explain the effect this mistake would have on the calculated relative atomic mass of the metal.

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(3)

(ii) The second student used 100 cm^3 of dilute hydrochloric acid instead of 50 cm^3.

Explain the effect, if any, this mistake would have on the calculated relative atomic mass of the metal.

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(3)
(Total 17 marks)

4. This question is about crude oil.

(a) The table shows information about crude oil fractions.

Crude oil fraction	**Number of carbon atoms**	**Approximate percentage (%) in crude oil**	**Approximate percentage (%) demand**
Gas	1–4	3	4
Petrol	5–10	9	23
Naphtha	8–12	10	5
Kerosene	9–16	14	8
Diesel	15–25	16	22
Residue	20–30+	48	38

Explain the advantage of cracking hydrocarbons.

Give **one** example from the table.

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(3)

(b) Ethene is a product of cracking.

Relative formula mass (M_r) of ethene = 28

Calculate the number of moles of ethene (C_2H_4) in 50.4 kg

Give your answer in standard form.

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Numbers of moles = ____________________

(3)

(c) $C_{21}H_{44}$ can be cracked to produce ethene.

$$C_{21}H_{44} \rightarrow 3C_2H_4 + C_{15}H_{32}$$

Relative formula mass (M_r) of $C_{21}H_{44}$ = 296

Calculate the mass of $C_{21}H_{44}$ needed to produce 50.4 kg of ethene.

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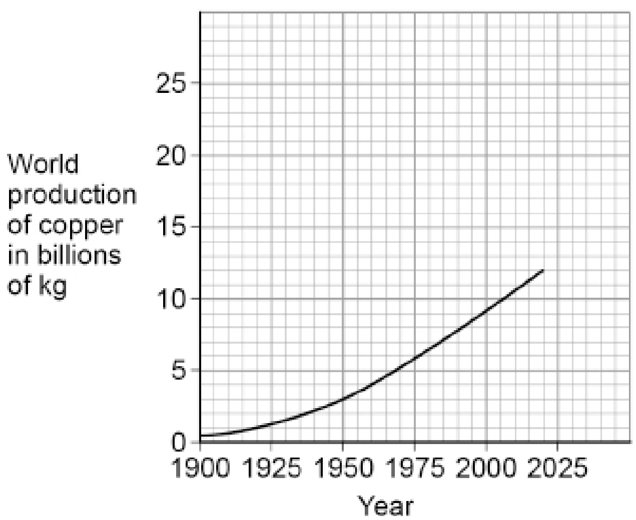
Mass = ________________________ kg

(3)

(Total 9 marks)

5. Industries use the Earth's natural copper resources to produce useful products.

The figure below shows the world production of copper from 1900 to 2020.



(a) Describe the trend shown by the graph in the figure above.

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(2)

(b) Suggest **one** reason for the trend in the figure above.

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(1)

(c) Suggest **one** reason why the trend cannot be used to accurately predict the future world production of copper.

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(1)

(d) High-grade copper resources are now difficult to find.

Phytomining is used to extract copper from low-grade ores.

There are five stages, **A**, **B**, **C**, **D** and **E**, in phytomining.

The stages are **not** in the correct order.

Stage **A**	Copper compounds from ash are dissolved in acid.
Stage **B**	Plants absorb metal compounds.
Stage **C**	Plants are burned.
Stage **D**	Plants are harvested.
Stage **E**	Solution of copper compound is electrolysed.

What is the correct order of stages **A**, **B**, **C**, **D**, and **E**?

Tick (✓) **one** box.

B, **C**, **D**, **E**, **A** ☐

B, **D**, **C**, **A**, **E** ☐

D, **B**, **C**, **E**, **A** ☐

D, **C**, **B**, **A**, **E** ☐

(1)

(e) Give **two** disadvantages of phytomining compared with traditional mining methods.

Do **not** refer to cost in your answer.

1 ____

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2 ____

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(2)

(f) In one year, 8.89×10^9 kg of copper was produced.

41.0% of this copper was produced from recycled copper.

The energy needed to produce 1 kg of copper from copper ore is 70.4 MJ.

The energy needed to produce 1 kg of recycled copper is 27.2 MJ.

Calculate the difference in energy used if all the copper was produced from recycling.

Give your answer to 3 significant figures.

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Difference in energy used (3 significant figures) = ________________ MJ

(5)

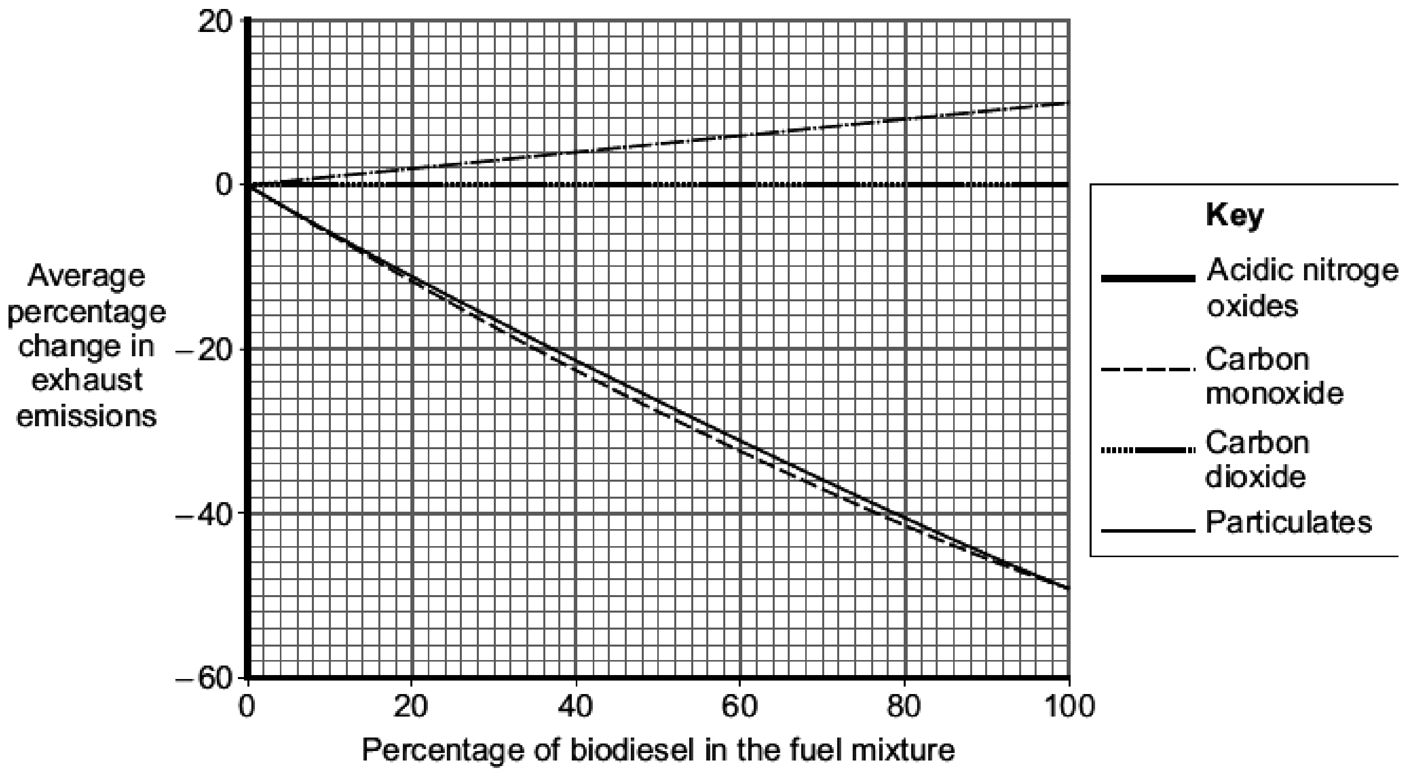
(Total 12 marks)

6. Petroleum diesel is produced from crude oil.

Most vehicles that use petroleum diesel as fuel can also use biodiesel or a mixture of these two fuels. In the UK (in 2010) there must be 5 % biodiesel in all petroleum diesel fuel.

Biodiesel is produced from plant oils such as soya. The crops used to produce biodiesel can also be used to feed humans. The benefit that biodiesel is 'carbon neutral' is outweighed by the increasing demand for crops. This increasing demand is causing forests to be burnt to provide land for crops to produce biodiesel. Only a huge fall in the price of petroleum diesel would halt the increasing use of biodiesel.

The graph shows the average percentage change in exhaust emissions from vehicles using different mixtures of petroleum diesel and biodiesel.



There is no difference in carbon dioxide emissions for all mixtures of petroleum diesel and biodiesel.

Use the information and your knowledge and understanding to evaluate the use of plant oils to produce biodiesel.

Remember to give a conclusion to your evaluation.

(5)

(Total 5 marks)

7. This question is about hydrocarbons and crude oil.

(a) Hydrocarbon fuels are produced from crude oil.

Describe how crude oil is separated into fractions.

(4)

Butane is a hydrocarbon.

(b) Two equations for the combustion of butane are:

- $2\ C_4H_{10} + 13\ O_2 \longrightarrow 8\ CO_2 + 10\ H_2O$
- $2\ C_4H_{10} + 5\ O_2 \longrightarrow 8\ C + 10\ H_2O$

Why are different products formed?

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(1)

(c) One other product of the combustion of butane is carbon monoxide.

Balance the equation.

$$\_\_\_\_\_\_\ C_4H_{10} + \_\_\_\_\_\_\ O_2 \rightarrow \_\_\_\_\_\_\ CO + \_\_\_\_\_\_\ H_2O$$

(1)

(d) Carbon dioxide is a greenhouse gas.

Describe the greenhouse effect in terms of the interaction of short and long wavelength radiation with matter.

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(4)

(Total 10 marks)

8. This question is about copper.

(a) Copper can be extracted by smelting copper-rich ores in a furnace.

The equation for one of the reactions in the smelting process is:

$$Cu_2S(s) + O_2(g) \longrightarrow 2\,Cu(s) + SO_2(g)$$

Explain why there would be an environmental problem if sulfur dioxide gas escaped into the atmosphere.

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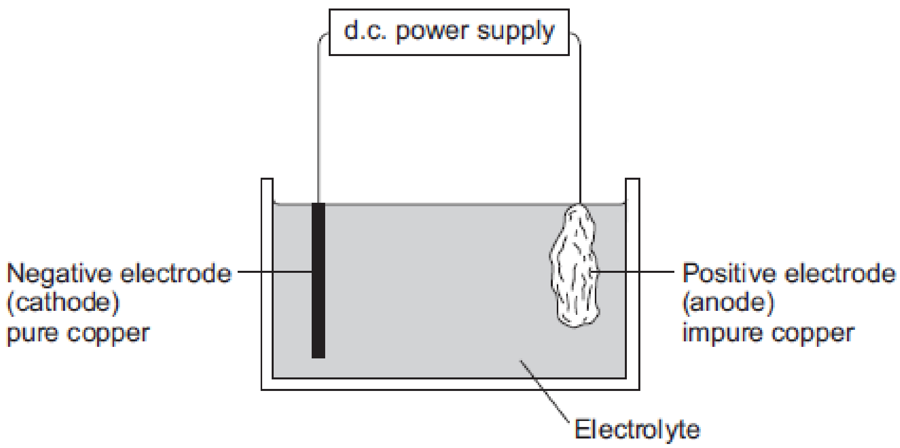
(2)

(b) The impure copper produced by smelting is purified by electrolysis, as shown below.



Copper atoms are oxidised at the positive electrode to Cu^{2+} ions, as shown in the half equation.

$$Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$$

(i) How does the half equation show that copper atoms are oxidised?

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(1)

(ii) The Cu^{2+} ions are attracted to the negative electrode, where they are reduced to produce copper atoms.

Write a balanced half equation for the reaction at the negative electrode.

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(1)

(iii) Suggest a suitable electrolyte for the electrolysis.

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(1)

(c) Copper metal is used in electrical appliances.

Describe the bonding in a metal, and explain why metals conduct electricity.

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(4)

(d) Soil near copper mines is often contaminated with low percentages of copper compounds.

Phytomining is a new way to extract copper compounds from soil.

Describe how copper compounds are extracted by phytomining.

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(3)

(e) A compound in a copper ore has the following percentage composition by mass:

55.6% copper, 16.4% iron, 28.0% sulfur.

Calculate the empirical formula of the compound.

Relative atomic masses (A_r): S = 32; Fe = 56; Cu = 63.5

You must show all of your working.

____

____

____

____

____

____

____

____

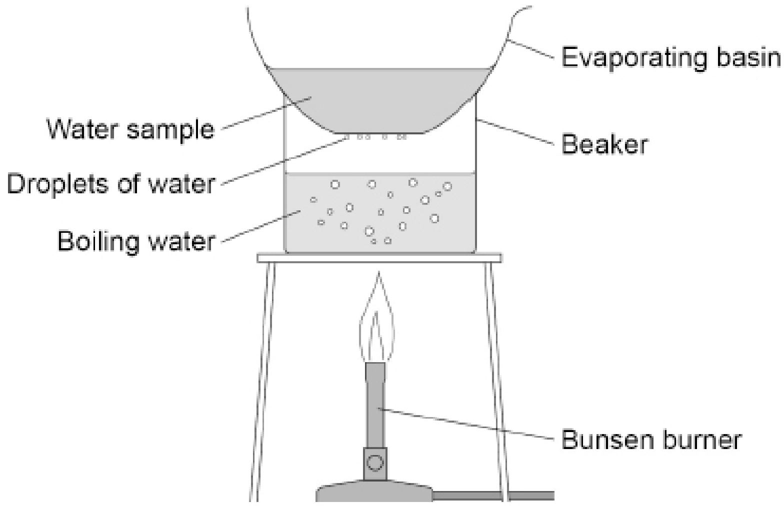
Empirical formula = ____________________

(4)

(Total 16 marks)

9. A student investigated the mass of dissolved solids in four water samples **A**, **B**, **C** and **D**.

The diagram below shows the apparatus used.



This is the method used.

1. Record the mass of a dry evaporating basin.
2. Pour 25 cm^3 of water sample **A** into the evaporating basin.
3. Place the evaporating basin on the beaker for 10 minutes.
4. Record the mass of the evaporating basin and contents.
5. Repeat steps 1 to 4 with water sample **A** three more times.
6. Repeat steps 1 to 5 with water samples **B**, **C** and **D**.

(a) What type of variable is the mass of dissolved solids?

Tick (✓) **one** box.

Categoric ☐

Control ☐

Dependent ☐

Independent ☐

(1)

(b) The method produced an error in the mass recorded in step 4.

Suggest what caused the error.

How could the error be avoided?

Error ____

____

Avoided by ____

____

(2)

Another student carried out the investigation correctly.

The table below shows the results.

Water sample	**Mass of dissolved solids in g**				
	Test 1	**Test 2**	**Test 3**	**Test 4**	**Mean**
A	0.22	0.23	0.20	**X**	0.21
B	0.03	0.08	0.02	0.03	0.04
C	0.45	0.60	0.49	0.58	0.53
D	0.80	0.91	0.79	0.86	0.84

(c) Calculate value **X** in the table above.

____

____

____

____

X = ________________ g

(2)

(d) Which water sample has the greatest range of masses of dissolved solids?

Give the reason for your answer.

Water sample ________________

Reason ____

____

____

(2)

(e) Water companies measure the volume of water used by households in cubic metres (m^3).

25 cm^3 of a different water sample contained 0.016 g of dissolved solids.

Calculate the mass of dissolved solid in 1 m^3 of this water sample.

1 m^3 = 1000 dm^3

Give your answer in standard form.

____

____

____

____

____

____

____

____

Mass (in standard form) = ____________________ g

(4)

(Total 11 marks)

10. This question is about chromatography of food colouring.

(a) Food colouring is a formulation.

What is a formulation?

____

____

(1)

(b) Explain how paper chromatography separates the dyes in a food colouring.

Do **not** give details of how to do the experiment.

____

____

____

____

(2)

(c) Explain how the student could tell from the chromatogram that the food colouring contained more than one dye.

___

___

___

___

(2)

(d) Explain how the student could use chromatography to identify unknown dyes in the food colouring.

___

___

___

___

___

___

(3)

(Total 8 marks)

Mark schemes

1. (a) when a reversible reaction occurs in apparatus which prevents the escape of reactants and products

allow when a reversible reaction occurs in a sealed system

1

(equilibrium is reached) when the forward and reverse reactions occur at (exactly) the same rate

1

(b) (as pressure increases) the equilibrium position shifts to the right hand side

allow (as pressure increases) the percentage of product / dinitrogen tetroxide / N_2O_4 increases

1

(because) there are less moles / molecules (of dinitrogen tetroxide) on right hand side

allow (because) there are more moles / molecules (of nitrogen dioxide) on left hand side

1

(c) (as temperature increases) equilibrium position shifts to left hand side

1

(because the forward) reaction is exothermic
or
(because) the backward reaction is endothermic

1

(so) the percentage of product / dinitrogen tetroxide / N_2O_4 decreases

1

[7]

2. (a) small molecules

1

with weak intermolecular forces

1

(so) only a small amount of energy is needed to separate the molecules

any reference to bonds being weak or being broken negates the second and third mark unless they are stated to be intermolecular bonds or bonds between molecules

1

(b) decreases

1

because the equilibrium shifts in the endothermic direction

allow reverse reaction favoured if forward reaction is exothermic

1

(c) increases

1

because there are more molecules of gas on the left-hand side

or converse

1

[7]

3. (a) left hand: (conical) flask

*do **not** accept round bottomed flask or container which is not a flask*

1

right hand: beaker / trough

accept plastic box

1

(b) (i) 157

1

(ii) all calcium carbonate used up **or** reaction stopped

*do **not** accept all acid used up*

1

(c) (i) 0.007(272727…)

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow (0.32 / 44) for **1** mark*

2

(ii) 0.007(272727…)

*allow ecf from **(c)(i)***

1

(iii) (M_r = mass / moles = 1 / 0.00727…) = 137.5 or 138

*allow ecf from **(c)(ii)***

if use 0.00943 moles then = 106

if use 0.007 allow 143 (142.857)

1

(iv) (138) – 60 (= 78)

23 / 85

1

(78 / 2) = 39

1

potassium

sodium / rubidium

*identity of metal ecf on A_r, but **must** be Group 1*

*If no working max **1** mark*

1

(d) (i) (relative atomic mass) would decrease

1

because the mass lost greater

1

so moles carbon dioxide larger **or** moles metal carbonate greater

1

(ii) no change

1

because the acid (already) in excess

1

so the amount carbon dioxide lost is the same

1

[17]

4. (a) break large molecules into small molecules

1

to satisfy demand

1

example

1

(b) 50.4 kg = 50 400 g

1

50 400/28

1

1.8×10^3

1

(c) 1.8/3 = 0.6

1

0.6 × 296

1

= 177.6 kg

1

[9]

5. (a) production of copper is increasing

1

at an increasing rate

1

(b) increase in population / demand

allow more uses for copper

1

(c) any **one** from:

- more use of recycling
- copper is a finite resource and may run out
- alternative metals may be used in future

ignore only an estimate

1

(d) **B**, **D**, **C**, **A**, **E**

1

(e) any **two** from:

- (phytomining is) slower to produce copper
  ignore reference to cost
  ignore references to carbon dioxide
  ignore references to global warming
  allow plants grow slowly
- large area of land required
- insufficient yield to meet demand

2

(f) (energy use through recycling =
$27.2 \times 8.89 \times 10^9 \times \frac{41}{100}$)

$= 9.914 \times 10^{10}$

1

(energy use through extraction =
$70.4 \times 8.89 \times 10^9 \times \frac{59}{100}$)

$= 3.693 \times 10^{11}$

1

(total consumption today =
$9.914 \times 10^{10} + 3.693 \times 10^{11}$)

$= 4.6844 \times 10^{11}$

allow correct use of an incorrect energy use determined in MP1 and/or MP2

1

(energy use if only recycling used = $27.2 \times 8.89 \times 10^9$)

$= 2.418 \times 10^{11}$

1

(energy saving =
$4.6844 \times 10^{11} - 2.418 \times 10^{11}$)

$= 2.27 \times 10^{11}$ (MJ)

allow an answer correctly calculated to 3 significant figures which uses the values in the question

1

[12]

6.

any **four** from:

*to gain **4** marks both pros and cons should be given*

Arguments for biodiesel

max **three** from:

- sustainable / renewable
- (carbon neutral) absorbs CO_2 when growing / during photosynthesis
- burning biodiesel produces low amounts particulates / carbon monoxide

  allow burning biodiesel produces little / low amount of global dimming

  ignore sulfur dioxide
- can use waste vegetable oils / fats (from food industry) **or** can use waste plant material
- can be used to conserve crude oil (instead of / mixed with petroleum diesel)
- produced by a low energy / temperature process

  accept produced by a low tech process
- biodegrades (easily)

  ignore engine effects

Arguments against biodiesel

max **three** from:

- creates food shortages

  accept price of food increases
- deforestation to plant more crops leads to loss of habitat / biodiversity **or** deforestation leads to a reduction in absorption of CO_2

  allow burning trees increases CO_2

  allow deforestation increases global warming
- burning biodiesel produces high amounts of nitrogen oxides

  allow increases acid rain
- crops takes time to grow

  allow crops can fail
- vast areas of land needed to grow crops

4

conclusion supported by the argument presented, which must give added value to the points for and against given above

1

[5]

7. (a)

*maximum of **3** marks if incorrect reference made to cracking*
ignore fractional distillation
ignore fracking

heat or vaporise (oil)

1

temperature gradient in column

allow column is cooler at the top
or
allow column is hotter at the bottom

1

(vapour) condenses (into fractions)

1

depending on boiling point of fraction

allow at different levels

1

(b) different amounts of oxygen available

*allow complete combustion **and** incomplete / partial combustion*

1

(c) $2\ C_4H_{10} + 9\ O_2 \longrightarrow 8\ CO + 10\ H_2O$

allow correct multiples / halves

1

(d) short wavelength radiation which enters the atmosphere

because uv / ultra violet radiation which enters the atmosphere

1

is absorbed by materials **and** re-emitted

1

as a longer wavelength radiation

as ir / infrared radiation

1

(the longer wavelength radiation is trapped by) a greenhouse gas / carbon dioxide / methane which stops radiation escaping (from the atmosphere)

allow so temperature increases

1

[10]

8. (a) because sulfur dioxide causes <u>acid rain</u>

1

which kills fish / aquatic life **or** dissolves / damages statues / stonework **or** kills / stunts growth of trees

if no other mark awarded then award 1 mark for sulfur dioxide is toxic or causes breathing difficulties.

1

(b) (i) <u>electrons</u> are lost

1

(ii) $Cu^{2+} + 2e^{-} \rightarrow Cu$

allow $Cu^{2+} \rightarrow Cu - 2e^{-}$

ignore state symbols

1

(iii) copper sulfate

allow any ionic copper compound

1

(c) (lattice of) positive ions

1

delocalised electrons

accept sea of electrons

1

(electrostatic) attraction between the positive ions and the electrons

1

electrons can move through the metal / structure **or** can flow

allow electrons can carry charge through the metal / structure

if wrong bonding named or described or attraction between oppositely charged ions then do not award M1 or M3 − MAX 2

1

(d) (copper compounds are absorbed / taken up by) plants

allow crops

1

which are burned

1

the ash contains the copper compounds

do not award M3 if the ash contains copper (metal)

1

(e)

/ A_r	55.6 / 63.5	16.4 / 56	28.0 / 32
moles	0.876	0.293	0.875
ratio	3	1	3
formula	Cu_3FeS_3		

*award **4** marks for Cu_3FeS_3 with some correct working*

*award **3** marks for Cu_3FeS_3 with **no** working*

*if the answer is not Cu_3FeS_3 award up to **3** marks for correct steps from the table apply ecf*

*if the student has inverted the fractions award **3** marks for an answer of $CuFe_3S$*

4

[16]

9. (a) dependent

1

(b) not all water had been removed from the sample

allow description of process

1

heat to constant mass

1

alternative approach:

mass included (droplets of) water on the bottom of the evaporating basin (1)

allow bottom of evaporating basin was wet
ignore spillages
ignore weighing errors

dry the bottom of the evaporating basin (1)

allow wipe off droplets

(c)

$$\frac{0.22 + 0.23 + 0.20 + X}{4} = 0.21$$

1

(**X** =) 0.19 (g)

1

(d) **C**

*allow ecf from question **(c)***

1

biggest difference between the maximum and minimum values

*allow calculated range if all ranges are shown **A** 0.04; **B** 0.06; **C** 0.15 and **D** 0.12*

1

(e) (conversion m^3 to cm^3) $1\ m^3 = 1 \times 10^6\ cm^3$

1

(mass =) $1 \times 10^6 \times \frac{0.016}{25}$

allow correct use of an incorrect / no conversion value

1

= 640 (g)

1

= 6.4×10^2 (g)

allow a correctly calculated answer in standard form from an incorrect calculation of mass

1

[11]

10. (a) a mixture designed as a useful product

1

(b) dyes distributed differently between the stationary and mobile phase

allow dyes have different solubilities

allow dyes have different forces of attraction for stationary phase

allow dyes have different forces of attraction for mobile phase

allow dyes have different forces of attraction to the paper

allow dyes have different forces of attraction to the solvent

ignore density

1

(so dyes) move up the paper at different speeds / rates

allow (so dyes) move different distances up the paper

ignore references to time

1

(c) (because chromatogram has) different dots / colours

1

in a (vertical) column

allow above the (original) spot

1

(d) run known dyes and food colouring (as a chromatogram)

1

compare distances moved
or
compare R_f values

(so) can identify those that move the same distance as known dyes

allow (so) can identify those that move different distances as unknown dyes

or

(so) can identify those that have the same R_f values as known dyes

allow (so) can identify those that have different R_f values as unknown dyes

1

[8]